METALLURGIA

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(Incorporating The Metallurgical Engineer.)

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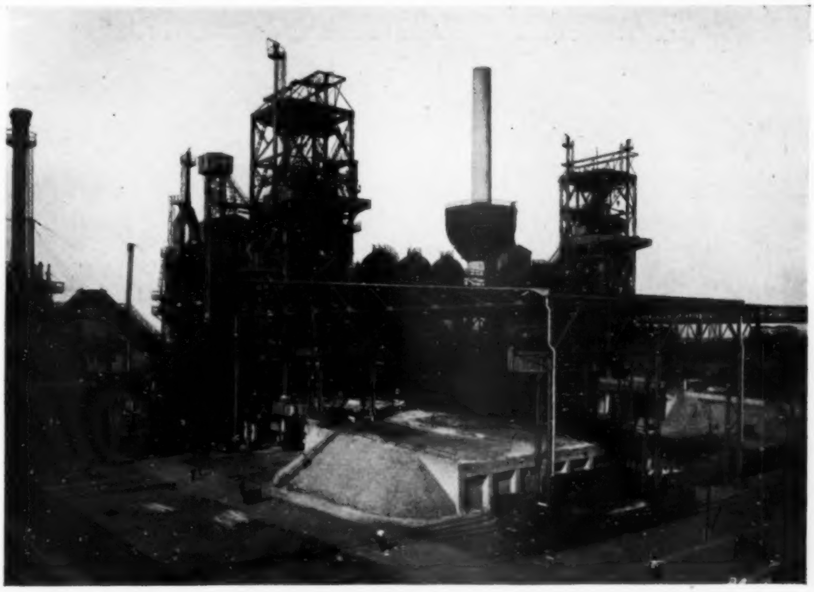
Development of the Krupp Works at Essen

Founded in the years 1811-1812 by Friedrick Krupp, primarily with the object of producing English crucible steel, the Krupp Works have developed from a small beginning into one of the most prominent industrial concerns of Germany and even of the whole world. In this article is given a brief description of these works, together with a reference to the ramifications of the Company and its chief products.

(*Specially contributed.*)



Blast-furnace plant at Essen-Borbeck, Fried. Krupp Achtiengesellschaft, Essen.

FOUNDED nearly 125 years ago as the Essen Cast Steel Works, the Krupp Works have grown into one of the most prominent industrial concerns of Germany. At that time English crucible steel had been excluded from European markets owing to the blockading of England by Napoleon I, and the object of Friedrick Krupp, the founder, was the production of this type of steel. To-day, the firm of Fried. Krupp A. G. is one of the oldest and best-known iron and steel-making concerns in Europe, owning coal and iron ore mines, blast-furnace plants and steel works, foundries, forges and rolling mills, engineering works, and a shipyard. Ores from oversea are transported by the Company's own fleet of steamers. For the purpose of securing command of unfailing supplies of raw materials and creating a steady outlet for its manufactures, the Company has acquired a controlling interest in a number of other manufacturing firms and trading companies, while a wide-flung net of agencies and distributing organisations, and long-standing relations with commercial houses of the highest standing in all countries keep the Krupp enterprises in close touch with the business life of the world. The share capital of the Company is 160 million Reichsmarks, and and balance sheet as at September 30, 1933, shows assets totalling about 390 million Reichsmarks. On October 1, 1934, the Company gave employment to 75,200 men, including the staff.

The Essen Works.

The original undertaking and parent establishment of the Krupp organisation is the "*Gusstahlfabrik*" (*Cast Steel Works*), situated at *Essen*, in the very centre of the Rhenish-Westphalian industrial district. The works comprise two main groups, a "Steel Section" and a "Mechanical Engineering Section." They occupy an area of about 2,150 acres. The site is bounded on the North by the Rhine-Herne Canal, and a private harbour branching off the latter, 765 yards long and 65 yards broad, affords excellent facilities for receiving and despatching goods by water.

The "Steel Section" at the Essen Works comprises :—

Blast-furnaces, two units, each having an output capacity of about 500 tons of pig iron a day.

Four separate Open-Hearth Plants with a total of 20 furnaces.

Electric steel plant of 9 furnaces.

Forging department for smith and die forgings, consisting of 77 steam hammers and 15 forging presses.

Two large forging-press shops installed with forging presses of 15,000, 5,000, 4,000 and 2,500 tons capacity.

Seven rolling mills for semi-finished material, medium and small structural sections, strip and wire rods.

Three plate and sheet mills.

One tyre-rolling mill and one wheel-rolling mill.

Three shops for the construction of railway wheel sets.

Pressed platework department with 16 flanging and drawing presses, having a total capacity of 10,000 tons per annum.

Spring department for the manufacture of springs for railway rolling stock and other uses.

Two large steel foundries producing castings weighing up to 160 tons.

Two grey-iron foundries.

View in open-hearth steel plant at Essen.

Two foundries for special castings.

One non-ferrous foundry.

Five extensive machine shops for finishing forgings and castings up to the largest dimensions.

Department for the manufacture of chemical apparatus, storage tanks and similar articles manufactured in non-rusting and heat-resisting steels.

Consistent high quality in production is ensured by the minute supervision exercised by the central Research Laboratory, which is equipped with the most modern chemical, physical, micrographic and electrical apparatus. This central Laboratory controls a considerable number of individual testing and experimenting stations spread over the entire works. The Research Laboratory is also continuously carrying out scientific investigations, which in the past have led to developments of outstanding importance in the metallurgical field.

Various Departments.

The principal products of the "Steel Section" are: high-grade special steels of every description, such as high-speed and carbon tool steels, "Widia" cutting metal for tipping tools, special constructional steels suitable for treatment by oil quenching, case-hardening and nitrogen-hardening, hard-wearing high-manganese steel, die steels, rifle barrel steels, steels possessing specific electric, magnetic, or thermal properties, non-rusting, acid-proof, and heat-resisting steels; semi-manufactures, bars, strip, and wire rods of special analysis steel; forgings of any size and description, steel and iron castings up to the largest sizes and of the most intricate shapes, malleable castings, non-ferrous castings, rolls for cold-rolling mills, weldless pressure vessels, parts for automobile, aircraft and engine construction, railway wheelsets and parts for same, springs, plates, sheets, and pressed platework.

The "Mechanical Engineering Section" comprises complete locomotive shops with a total capacity of 400 heavy locomotives per annum; a department for the manufacture of various types of petrol and Diesel-engined motor lorries, an agricultural machinery department, and complete plants for the manufacture of light railway material, railway and tramway points and crossings, excavating machinery, spoil transporters, complete gear drives up to the largest dimensions, toothed gearing of every description portable pneumatic and electric tools, an many other kinds of machinery and appliances.

Commercial grades of steel are produced at the "*Friedrich-Alfred-Hütte*" Iron and Steel Works at Rheinhausen, one of the largest and most up-to-date plants of its kind in Europe, located in an ideal geographical situation on the Lower Rhine, opposite the city of Duisburg-Ruhrort, the largest inland port of Europe and an important railway centre. The works occupy a total area of 1,621 acres.

The blast-furnace department at Rheinhausen comprises nine large blast-furnaces, and two smaller ones that are used for making high-grade ferro alloys. The furnaces stand in a line 1,325 yards long, facing the Company's harbour, which opens on the River Rhine and is equipped with ample facilities for rapidly loading and unloading vessels berthing at the quay.

The steel-making department, which receives most of its raw material in the form of hot metal, comprises six basic converters of 25 tons capacity each, and two open-hearth shops with eight furnaces in all; four of the latter, each of 160 tons capacity, being of the tilting type.

The rolling-mill department consists of 15 mills —*viz.*, three heavy blooming trains, five roughing, three intermediate, and three finishing trains, and one wire rod mill of very high capacity.

The establishment further includes a structural steel-work department producing riveted and welded steelwork of every description, such as bridges, steel-framed buildings, pit-head gears, lock gates, pontoons, storage tanks, lattice pylons, etc.

Engineering Works.

At Magdeburg on the Elbe are situated the "*Krupp-Grusonwerk*" *Engineering Works*, with a total area of 275 acres. Of the very comprehensive range of machinery manufactured there, the following chief lines may be briefly mentioned: crushing and grinding machinery for every kind of material, complete cement works equipment, coal screening, pulverising and mixing plant, ore dressing and smelting plant, rolling mills for ferrous and non-ferrous metals, cable-making and wire-rope machinery, roadmetal crushing and sizing machines, hydraulic baling presses and presses for other purposes, oil mill equipment, plant for the rubber, linoleum and allied industries, cranes, transporter bridges and conveyors, mechanical equipment for locks, weirs and other hydraulic engineering schemes, machinery for the cane sugar, fibre, rubber, coffee, teat and palm-oil industries.

Besides the above, the manufacturing programme of Messrs. Krupp-Grusonwerk includes chilled castings for many purposes, a field in which they have achieved a world-wide reputation.

Shipbuilding and Engineering Works.

The Company's Shipbuilding and Engineering Works, run under the style of *Fried. Krupp Germaniawerft A.-G.*, are situated at the innermost point of Kiel Cove, which extends inland for nearly 11 miles and is tideless. The available depth of water is at all times sufficient for launching the largest ships. The yard is 306 acres in area, and

General view of steel foundry at Essen.

has a water frontage of three quarters of a mile, on which are situated 8 building berths capable of accommodating vessels of very large size ; four of these berths are roofed in. In addition to cargo and passenger vessels, the yard specialises in steam- and oil-engined yachts, and oil tankers. The engineering department incorporated in the works builds Diesel engines, steam boilers, steam turbines, etc.

Iron Ore Mines.

The Krupp iron ore mines are situated chiefly in the Sieg and Lahn valleys, and at the time of writing furnish about 15% of the Company's total requirements. The coal mines owned outright or controlled by the Krupp Company all lie in the Ruhr basin. Their output quota in the Rhenish-Westphalian Coal Syndicate amounts to 11,6 million tons per annum, of which 3 million tons are consumed in the Company's own works.

An idea of the productive capacity of the Krupp enterprises may be gathered from the following figures : The blast-furnaces at Essen and Rheinhausen can produce up to 2 million tons of pig iron per annum. The structural steelwork department at Rheinhausen has a potential annual output of 40,000 tons. The spring-making department at Essen is in a position to supply springs of every description at the rate of 15,000 tons a year. The annual capacity of the wheelset department amounts approximately to 45,000 sets for rolling stock and 6,000 sets for locomotives. The ship-yard at Kiel is equipped to build yearly new ships up to an aggregate burthen of 100,000 tons.

Reorganisation.

World conditions since the end of 1918 have called for an entire reorganisation of the Krupp undertaking, and this has naturally led to very great extension of the Company's activities, particularly in mechanical engineering, such as locomotives, steam, Diesel and electric, motor lorries, agricultural machinery and excavators, to mention only a few of the principal new additions to the manufacturing programme. In spite of serious economic difficulties and world political disturbances, the work of reconstruction has been in continuous active progress, notwithstanding the very serious dislocation caused by the occupation of the Ruhr.

The year 1926 marks the beginning of a new period of intensive development and witnessed the realisation of long-planned improvements and extensions. Of the new plant installed at that time, a continuous semi-finishing mill on the Morgan system and a small-section mill, both erected at Rhein-hausen, as well as a two-furnace blast-furnace plant and a 15,000-ton forging press set in operation at the Essen works, deserve special mention. The press in question is employed for work on extra-heavy forgings, and has successfully dealt with ingots weighing no less than 250 tons.

15,000-ton steam hydraulic forging press.

Tapping an electric steel furnace.

The world-wide economic depression which set in about 1930 did not spare the Krupp enterprises. The year 1932, in particular, brought an unprecedented decline, the production of steel at the Essen works actually falling to the level of 1890.

Since the spring of 1933, as a consequence of the economic measures introduced by the National-Socialist Government, a marked revival of trade has been experienced, enabling the Company to again substantially increase the number of its employees.

Notwithstanding all post-war difficulties, notable technical progress has been made in many fields, which has not only maintained but has considerably enhanced the high reputation in which the Krupp products have always been esteemed throughout the world. Thus, the metallurgy of rust and acid-resisting steels of which material Krupps had been the pioneers as early as 1912, was developed to an extent that led to revolutionary changes in the construction of chemical plant, not to mention many other spheres of usefulness. The Company has further evolved a very successful series of steels possessing excellent scale-resisting properties combined with a high retention of strength at elevated temperatures. The problem of the ageing of steel has also been solved, with the result that any kind of steel can to-day be made practically non-ageing. The use of such steels for boiler plates, tubes and drums, as well as for aeroplane construction, greatly enhances immunity from breakdown. In the field of automobile and engine design, the "Nitriding" method of case-hardening evolved by the Company also marks an important advance. As compared with the carburising process of case-hardening, the nitriding process is more easily carried out and further imparts a higher degree of surface hardness. In addition, the well-known disadvantages of the carburising method, namely distortion of the articles so treated, and the formation of cracks on quenching, are avoided by the nitriding process, as the latter is performed at the low temperature of only 500° C., and no subsequent quenching is required. Some remarkable results have also been achieved by Krupp in the metallurgy of such steels as are required to possess specific physical properties, as well as in welding technique.

Some Examples of Work Carried Out.

Of important work carried out of late years by the Company in fields other than the above, only a few examples will be given in what follows.

The steelwork for the great railway bridge over the Little Belt (Denmark) was designed and manufactured at the Rheinhausen Works. The Krupp-Grusonwerk at Magdeburg has designed and built the largest jaw crusher in the world. The largest forgings that have so far been fashioned by the new 15,000-ton hydraulic press at the Essen works, are represented by four forging press columns, each about 70 ft. long and 113 tons each finished weight, and three hollow forged vessels weighing over 100 tons each in the finish-machined condition. The Krupp shipyard at Kiel has built and engined the three largest American-owned cruising yachts afloat (the "Nourmahal," "Hussar" and "Orion").

General view of laying-out shop for track work.

On the strength of such and other achievements, the Krupp enterprise can face the future with full confidence, The success of its activities in the domains of metallurgy, mechanical engineering and naval architecture affords a sufficient guarantee that it will at all times be able to hold its own against domestic and foreign competition.

The British Foundry School

A new type of specialised school intended for those who wish to qualify for positions of the highest responsibility.

MEETINGS have recently taken place which have resulted in the formation by the founding industry of a provisional Governing Body for an entirely new type of specialised school, the British Foundry School. If sufficient students present themselves, it will be opened in September of this year. From the prospectus that has been issued we learn that the School is intended for those men who wish to qualify for positions of the highest responsibility in the foundry industry or who have already achieved such positions and who wish to extend their metallurgical and technical knowledge to meet the advances made in recent years. It is primarily intended for chemists, engineers and metallurgists, and even managers, of establishments concerned with the founding of grey iron, white and chilled iron, malleable cast iron, steel and the non-ferrous metals, particularly those who have already had some practical experience and who wish to qualify for, or who have already shown their capacity in, managerial and supervising posts. The School provides a full-time day course of one year's duration and successful students will receive the Diploma of the School. It is expected that the Diploma will receive endorsement by the Board of Education.

Out of a net running cost (total expenditure less receipts from students' fees, fixed at £30 per annum) of £2,000 per annum, the Board of Education has undertaken to provide £1,500 in the form of grant, provided the remaining £500 is forthcoming from the industry. Of this latter sum, nearly one-half has been promised by a group of institutions representing the industry which are supporting the School and which have nominated representatives to the Governing Body. The industry is now invited to contribute the remainder, about £300 per annum. It is felt that the industry will welcome the opportunity of showing its sense of the need for the School by contributing this comparatively small sum. It is well known that vacancies for foundry managers and foremen who can combine metallurgical and technical knowledge with managerial experience are difficult to fill.

Schools for the higher training of foundrymen have been established in France and Germany and the remarkable advances which are now being made in founding necessitated provision of the kind indicated being made for this country.

The bodies who are in various ways concerned with this industry and who are supportiug the school are the British Cast Iron Research Association; British Iron and Steel Federation (Iron and Steel Industrial Research Council); British Non-Ferrous Metals Research Association; City and Guilds of London Institute; Institute of British Foundrymen; Institute of Metals; Institution of Automobile Engineers; Institution of Mechanical Engineers; Iron and Steel Institute; National Light Castings Ironfounders' Federation; and the Welsh Engineers and Founders' Association.

Through the public-spirited action of the Birmingham Education Committee, the School will be housed in the Metallurgical Department of the Central Technical College. Mr. R. G. Hosking has been appointed Chairman of the provisional Governing Body, Alderman W. Byng Kenrick Vice-Chairman, and Mr. J. G. Pearce Honorary Adviser and Honorary Treasurer, to whom contributions and requests for information may be sent, at 21, St. Paul's Square, Birmingham, 3. Prospective students should apply as soon as possible.

No attempt will be made to give students practical experience in founding or patternmaking, as this can only be acquired in a foundry. The curriculum will include the development and structure of the foundry industry, and its various divisions, both at home and abroad, and the organisation and planning of foundries, including costing. The raw materials, equipment and processes of the industry will be dealt with fully, along with the metallurgy of cast iron, cast steel and the cast non-ferrous metals. Laboratory instruction will be provided in mechanical testing, microscopical examination and chemical analysis, the testing of sands and refractories and in foundry technique.

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EXPORT TRADE AND PROSPERITY

WHAT an amazing change would take place if human beings were enabled to consume existing surpluses, and the immense additional quantities of wealth which could rapidly be made available if resources in land, raw material, human labour, and capital equipment were employed to their maximum capacity. It would then be realised that the only rational reasons for exports would be either to pay for imports or to pay the interest and amortisation due in respect of capital goods imported previously. In addition, of course, there would be an excess of imports to pay for services rendered to the world by creditor nations. Unfortunately, the nations of the world favour a policy of economic nationalism, which finds expression in high tariffs, import restrictions, quotas and limitation on the export of currency. In other words every effort is being made to restrict international trade upon which the prosperity of the world largely depends. There is very keen competition to sell in the world's markets, but in many countries the desire to buy in these markets is frowned upon as anti-national.

In Great Britain there are indications that the forces of recuperation are bursting these bonds of artificial restriction of the world's trade, and her trade is showing signs of recovery. Recent monthly returns show that exports increased by £2,447,000, as compared with a similar period last year, and by £4,441,000, as compared with the same month in 1933. This improvement in overseas trade follows a general improvement which has been apparent each successive month during this year. It is noteworthy that it is in manufactured goods that the main improvement is found, such as, electrical goods, iron and steel, cotton, locomotives, ships and aircraft. During the same period imports also show an increase: £2,735,000, as compared with the same period last year and £7,256,000 with 1933. In these imports only one amongst the manufactured articles shows a very large increase; this is under non-ferrous metals, which may be regarded as raw material. From the latter it may be assumed that production is likely to remain at a satisfactory level for some time to come.

Recent unemployment figures seem to support the fact that a substantial degree of recovery has been achieved in this country. The iron and steel industry is maintaining an upward tendency in production and is absorbing more labour. Improved conditions also exist in the non-ferrous industries, while the automobile and aircraft industries are amongst those which show much progress; in the main, however, the reduction in unemployment figures in Great Britain is due mainly to improved trade in the home markets which have developed during the period of transition from crisis to recovery. Though recovery is definitely in progress it should not be overlooked that over 2,000,000 remain unemployed and much headway must be made before recovery in trade and industry can have its proper significance. It is profitable to analyse this figure and determine if possible how it is distributed over the country. Unemployment percentages are highest in the North East, North West, Scotland and Wales districts. These areas, which have approximately half of the population, have roughly 1,400,000 unemployed—*i.e.*, nearly three-quarters of those reported in the whole country. Not only is unemployment concentrated in these areas, but it is becoming more concentrated. Three years ago, it is stated that these areas accounted for 63.5% of the total unemployment; the recent figures show that this has risen to 70·5%.

The remarkable thing about this analysis is that unemployment is becoming more and more a question of the very depressed areas and trades, which are predominantly the export trades and those that serve them. It can be said with confidence that one half of the country is really in a prosperous condition; these are the good areas which deal more particularly with the home trade and a general stimulus to improved trade is not now so essential as a policy which is likely to stimulate work in the depressed areas. What is wanted is a revival of greater magnitude in the export trade.

In industrial circles there is general satisfaction concerning the five-years agreement with the International Steel Cartel, particularly from the point of view of home consumption, since the effect of the agreement should result in much greater production by the home industry next year. Even if home consumption is on a similar average level as for this year, about 400,000 tons more will require to be produced in this country. With the gradual improvement in trade, however, this amount may be considerably exceeded: there is no doubt that more steel will be produced, and this will not only be of substantial benefit to the iron and steel industry, but also to the coal-mining industry and many ancillary trades. The domestic demand for iron and steel has improved very considerably, particularly the demand for structural steel; in the automobile industries also a new high level in the demand for steel has been reached, but, in shipbuilding and the older industries, the demands for materials have been much slower and such improvement as has been effected is relatively small, and whether the new agreement with the Steel Cartel will assist exports of steel is doubtful. Thus those industries and trades in the depressed areas are not participating in the increased demands for steel, with the result that iron and steel works in these areas are operating well below capacity.

The erection of the proposed new tinplate works at Redbourn by Richard Thomas and Co., is a disquieting thought for the Welsh tinplate workers. If the scheme materialises and the manufacture of tinplate by this firm is transferred to Lincolnshire it is likely that an area which has already suffered heavily as a result of the long depression will suffer a further substantial setback.

It is probable that the home markets are approaching saturation point and that any further substantial improvement will depend upon increased export trade; this is controlled by world economic conditions and it is in the wider sense that political influences are especially desired to establish better trading facilities overseas for British manufactures. Throughout the world the economic position remains difficult, though it is no longer so precarious as it was and some tentative lines of recovery, if not of rapid advance, have been tried. By comparison with 1932, for instance, the situation has certainly improved, and is still improving, but the paralysis and pessimism of that year have left their mark in general instability and uncertainty, in depreciated currencies and other trade-restricting policies. With greater concentration on overseas markets, we believe that the progressive spirit manifest in British trade by the recent returns will be cumulative and the depressed areas and trades will enjoy a share of the prosperity other areas are now experiencing.

Jubilee Meeting of North-East Coast Institution of Engineers and Shipbuilders

A very comprehensive programme has been prepared by the North-East Coast Institution of Engineers and Shipbuilders for its Jubilee Meeting to be held on July 16 to 19, at Newcastle-on-Tyne. By the courtesy of the Council of Armstrong College, the meeting will be held in the College. On the evening of July 16, guests will be received in the King's Hall by the Principal and Lady Morris, on behalf of the Council of Armstrong College, and by the President and Mrs. John T. Batey, on behalf of the Council of the Institution. A number of laboratories will be open. In the physics laboratory Professor W. E. Curtis, D.Sc., F.R.S., will give a short demonstration of the properties of waves by means of ripple tank and other apparatus.

Preceding the official meeting the following morning, a Thanksgiving Service will be held at St. Thomas's Church, Barras Bridge. The service will be conducted by the Rt. Rev. the Lord Bishop of Newcastle-on-Tyne and the Vicar of St. Thomas's. At the official meeting delegates representing kindred institutions and societies in Great Britain and Overseas will be welcomed. Several conferments and presentations precede the reading of three papers dealing with developments in the construction of ships during the past fifty years; these include :—" Liners " by Mr. J. Denham Christie ; " Cargo Ships and Tankers," by Mr. J. McGovern, and " Coasters," by Mr. F. W. Dugdale.

During the afternoon of July 17, a Garden Party will be held at Blagden Hall, by invitation of the Rt. Hon. the Viscount Ridley and the Viscountess Ridley. In the evening a Banquet and Dance takes place at the Grand Assembly Rooms, Barras Bridge.

During the morning of July 18 a technical session will be held, at which several papers will be presented dealing with various aspects of the developments in the construction of marine engines during the last fifty years ; these include :— " Turbines," by Mr. R. J. Walker ; " Reciprocating Steam Engines," by Mr. Summers Hunter, Junr. ; " Boilers," by Mr. T. McPherson ; and " Marine Heavy-Oil Engines," by Mr. K. O. Keller. A paper will also be presented by Mr. M. G. S. Swallow dealing with " Recent Progress in Electrical and General Engineering."

The programme includes visits to many important works in the district and special facilities are made for ladies to visit several places of interest for which the North-East Coast is noted.

The first general meeting of this Institution was held on November 28, 1884, and the activity to which the founders first set their hands was the procuring, reading, discussion and publication (with reports), of papers on engineering and shipbuilding, and that broadly describes the normal work year by year during the past half century. The Institution was, however, at once recognised as a representative body and called upon to express the attitude of the industries and professions from which its members were drawn, on broad technical and educational questions. To-day its work is known and appreciated not only on the North-East Coast but in all shipbuilding and marine engineering centres throughout the world and there is a world-wide interest in this Jubilee Meeting.

Corrosion tests were recently carried out in a large sewage disposal plant in America with a view to discovering the most economical material to resist the attack of the sewage corrosive handled. The results obtained from test specimens located in different parts of the plant show that cast iron and steel are attacked from four to twenty times faster than Ni-Resist, and that copper is attacked from two to three times faster. The resistance to wear offered by Ni-Resist also adds to its value for components subjected to abrasion, such as occurs in pump valves, screw conveyers, and scrapers.

Bismuth, Cadmium, and Selenium Production in Canada, 1934

THE Dominion Bureau of Statistics at Ottawa, reports that Canada's bismuth production last year totalled 253,644 lb. ($301,215), as compared with 78,303 lb. ($81,526) in 1933. Cadmium production was valued at $91,019, as against $78,733 in 1933. These metals are recovered in the metallurgical treatment of the lead-zinc ores of British Columbia, at Trail, B.C. At the same time, a silver-lead-bismuth bullion is produced at Deloro, Ontario, in the treatment of the silver-cobalt ores of northern Ontario, although the actual refining of the metal is carried out in the United States. A cadmium precipitate is also produced at the Flin Flon mine in Manitoba by the Hudson Bay Mining and Smelting Co., Ltd.

The production of selenium in Canada in 1933 totalled 48,221 lb., valued at $70,345, the output being obtained as a by-product in the electrolytic refining of copper in Quebec and Ontario. Canada is now in a position to produce selenium in considerable quantities, but the market is restricted at present to the glass and pottery industries, to its use in the photo-electric cell (electric eye) and to selenium cells in television. At the same time, it is used in stainless steel for developing improved cutting and threading qualities, whilst it is believed that a potential market exists in certain rubber compounding industries.

Royal Society of Arts

The Society's Albert Medal for 1935 has been awarded, with the approval of the President, H.R.H. the Duke of Connaught, to Sir Robert A. Hadfield, Bt., F.R.S., " for his Researches in Metallurgy and his Services to the Steel Industry." The Society's Albert Medal is awarded annually " for distinguished merit in promoting Arts, Manufactures or Commerce."

Bibliography of Non-Metallic Inclusions in Iron and Steel

Despite the excellence of modern indexes to technical literature there is, on most subjects, a good deal of elusive material which must be sought outside the formal approach through existing indexes and abstracts. Thus, for instance, printed information on non-metallic inclusions in iron and steel is widely scattered, specific information often concealed under general subjects, and the terminology often extremely confused; and before an adequate study of a line of work can be commenced the investigator is confronted with a tremendous mass of data which has accumulated. This is particularly true in the field of inclusions in steel.

Investigators in all steel manufacturing countries have spared no pains in attempting to evaluate the true status of inclusions in steel. This is extremely difficult from the very nature of the problem and the large number of variables involved. The consumer is constantly calling for clean steel and the manufacturer is endeavouring to meet these demands by improved practice. Some indication of the importance with which the subject of non-metallic inclusions in ferrous materials is regarded, is given by the extent of this bibliography, which, with the index, occupies 308 pages. It is noteworthy that it has been especially useful in connection with the programme of investigations on " The Physical Chemistry of Steel Making " which has been carried out under the direction of Dr. C. H. Hertz, Junr., since 1926.

This bibliography, though dealing with gaseous and solid non-metallic inclusions, does not attempt to include all allied subjects. For example, piping of ingots has been included only when it has some bearing on inclusions, the X-ray examination of metals has been omitted because an earlier bibliography has been completed on the subject. This compilation, however, is very comprehensive and will be invaluable as a guide to those working in this field.

Compiled by LOIS F. MCCOMBS and MORRIS SCHRERO ; published by Mining and Metallurgical Advisory Boards, Pittsburg, Pennsylvania, U.S.A. Price $4.00.

Non-Metallic Inclusions in Steel

The Inclusion Count as a Method of Expressing a Quality Factor

By G. R. BOLSOVER, F.Inst.P.,
Chief Metallurgist, Messrs, S. Fox & Co., Ltd.

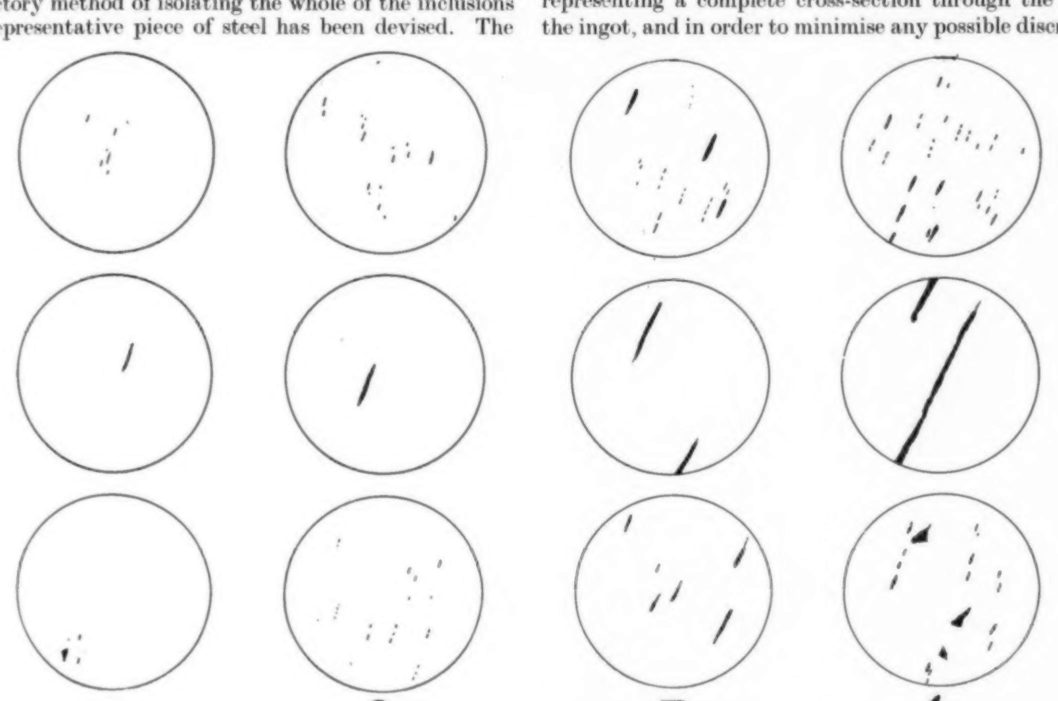
Much work has been carried out, not only on the mechanical properties of steel but on the subject of non-metallic inclusions and methods of expressing a quality factor from the point of view of non-metallic inclusions. In this article the author describes a method adopted by him, known as the inclusion count, which is in regular use and has proved of considerable help to the steelmaker.

FROM time to time, most people concerned with the examination of steel have felt the need for a quantitative system for the determination of non-metallic inclusions in steel. In the different steel-producing countries of the world various methods have been developed which have included both the actual separation of the non-metallic inclusions and also the microscopical examination of polished sections, but up to the present no completely satisfactory method of isolating the whole of the inclusions on a representative piece of steel has been devised. The success so far achieved in this direction has required long and tedious laboratory technique.

Not only do those responsible for reception tests on steel supplies feel the call for a definite system of examination, but the question becomes of very serious importance to the steel producer when experimental work is undertaken with a view to the production of steel of the utmost possible cleanliness.

The examination of isolated samples from different casts of material gives neither a complete nor necessarily a true picture of the grading of the particular cast under observation, and even when all precautions are taken to achieve this end, it is most difficult to compare results from cast to cast without a definite quantitative system. In view of this it is felt that a brief account of the system finally adopted in the Research Department of Messrs. S. Fox and Co., Ltd., during investigations into the production of the DIAMET steel, might prove of interest and advantage to producers and users of steel alike.

For examination purposes representation of the complete ingot section is obtained by taking a sample from the top, middle and bottom of the ingot; each sample is forged or rolled into a bar $1\cdot\frac{3}{8}$ in. diameter which is cut longitudinally through the axis of the bar. The sawn face is then prepared for micro-examination. Examination from edge to edge of the specimen—*i.e.*, across the axis, gives a picture representing a complete cross-section through the axis of the ingot, and in order to minimise any possible discrepancy by the examination of a single plane the sample is examined on two such lines.



1 2 3 4

Set of micrographs representative of the range of inclusion groups found in steel of various types. (Illustration half original size.)

By the adoption of a standard magnification of 130 diameters, a complete traverse of the section involves approximately 30 fields, this number having been taken as a standard. The examination of two different lines, as just described, results in the inspection of 60 fields for each specimen or sample.

In order to establish a quantitative basis for the correlation of the various results, a set of micrographs has been drawn, representative of the range of inclusion groups found in steel of various types, and these micrographs have been graded 1 to 4 in increasing order of severity of non-metallic matter. Of the 60 fields examined, the number of fields corresponding with each grade is multiplied by the grade number and the sum of the products of all the fields is adopted as the inclusion number for the sample of steel examined. Obviously, this inclusion number will increase with increasing quantity of non-metallic inclusions, and the

following example will explain more clearly the basis of assessment of the inclusion number.

Fields Examined.	Grade 1	Grade 2	Grade 3	Grade 4	Inclusion Count.
60	30	10	2	nil	$30 \times 1 = 30$
					$10 \times 2 = 20$
					$2 \times 3 = 6$
					Inclusion Number 56

It should be pointed out that in determining the grading for any particular field there will necessarily be, at times, some variation on either side of a particular number. Fields judged to correspond with less than half the quantity of inclusions indicative of Grade 1 are counted as "O," while from half grade 1 up to inclusions midway between 1 and 2—*i.e.*, $1\frac{1}{2}$, will be counted as Grade 1. From $1\frac{1}{2}$ to $2\frac{1}{2}$ is assessed at Grade 2, and so on.

In the set of micrographs used as standards and illustrating this article, each grade number includes three different micrographs, this having been done in an attempt partially to cover the variations in type and grouping of the non-metallic inclusions which occur in different steels. Again, the inclusions illustrated are essentially of the plastic type, and where a group of brittle inclusions is met with, this, for purposes of examination, is classified as if the units of the group were linked together to form a single plastic inclusion of total length equal to that of the group. The adoption of micrographs to cover all the possible variations of inclusion type would be so confusing as to render the system unworkable, whilst working with the illustrated standards the method has been found to work excedingly well for the examination of several hundred different specimens.

Naturally it is preferable to maintain standard conditions regarding the size of bar and the magnification employed, but consideration of the possible variants, confirmed by actual checking in the laboratory, indicates that appreciable latitude can be permitted in the particular conditions applied. For instance, an increase in the magnification gives a reduction in the number of non-metallic particles in a particular field, though the size of these will be increased. As the essential of this system of examination is the assessment of the quantity of steel as a background, provided sufficient of the section is examined, this should lead to the same inclusion number being determined. Further, if 60 fields in a 6-in. bar were examined instead of the same number in a $1\cdot\frac{3}{4}$-in. bar a similar result should be obtained. It will be realised that some slight, though minor, differences must arise by introducing the variations mentioned, since the comparisons would be absolutely true only if the quantity of non-metallics varied proportionately with the numbering of the grades. It has not been found advisable to adopt a grading of increasing the numbers proportionately with the inclusions, since firstly, by such a system all types of non-metallic inclusion groups could not be included and, secondly, it is doubtful whether the properties of the steel vary proportionately with the total size of given groups of inclusions found.

The system outlined has now been in regular routine operation for a very considerable time and the value of a system of quantitative registration of the non-metallic content of different heats of steel have been definitely proved to be of considerable help to the steel maker. By this inclusion count it has been found a relatively simple matter to give definite values to the different methods of steel manufacture, and so assess the influence of variables which can be introduced in the process of production.

Discovery of New Nickel Deposits in U.S.S.R.

Large nickel deposits, estimated at tens of thousands of tons, have been discovered by a survey party near the village of Akhermanivski, in the Orenburg Province of the U.S.S.R. The ore found is of an emerald-green colour, similar to the ores of New Zealand, a type of rich ore suitable for direct smelting. The new deposits lie within 25 kilometres of the construction site of the Orsk Nickel Plant.

Soviet Heavy Industry Production

THE value of the gross production of the industries under the jurisdiction of the Commissariat of Heavy Industry during the period January to May, was 9,212 million roubles (at 1926-27 prices). This was 40·5% of the plan. As compared with the corresponding period of last year gross production has increased by 25·2%.

The leading industries are some which, for years, have been backward. A few have already reached levels indicated in the five-year plan for 1937. For instance, the factories turning out agricultural machinery, which in past years have been somewhat backward, have increased their production of harvesters during the five months under review by five times, as compared with last year. They have turned out 12,053 harvesters. In consequence, it has been possible to increase the estimated plan for the year from 20,000 machines to 25,000. It is interesting to note that the figure indicated in the five-year plan for 1937 is only 20,000 harvesters.

There is also the case of rolling-stock. During the five months 29,114 goods trucks were produced. The annual plan is for 85,000. This is as much as heavy industry gave to railway transport during the past four years. The plan for the five months has been exceeded, and the truck-building industry is working so well that there is every reason to suppose that the heavy programme for the year, exceeding last year's programme by three times, will be carried out. This will ensure a sound material base for the better working of railway transport, signs of which are already visible.

At the last Party Congress, Stalin urged the necessity of strengthening the non-ferrous metal industry, particularly the copper industry. That this is being realised may be seen by the fact that the production of copper has increased by 67·5%. The directors of the Ural works have asked to have their annual programmes increased.

The gold industry is one of the leading industries in the national economy, and ferrous metallurgy, which is now producing over a million tons of pig iron per month, is confident of exceeding its annual plan.

The two exceptions are the coal and oil industry, which are still lagging behind, but signs are visible that an improvement in these two important industries will take place in the near future.

The achievements as well as the weak points in heavy industry are shown in the following provisional figures for the first five months of 1935:—

Industries.	Increase in production in 1935, as compared to 1934 in percentages. According to annual plan.	Actual increase for five months	Fulfilment of annual plan during the period Jan.–May in percentages.
FUEL.			
Coal	19·7	+ 12·8	37·7
Including the Donetz Basin	13·3	+ 10·2	39·0
Oil	18·2	+ 2·6	35·1
Including Azneft	17·0	+ 6·5	36·3
Peat	13·6	+ 25·0	26·1
FERROUS METALLURGY.			
Pig Iron	19·7	+ 24·6	39·6
Steel	23·4	+ 31·7	41·4
Rolled Metal	22·0	+ 29·6	41·2
NON-FERROUS METALLURGY.			
Copper	33·2	+ 67·5	42·5
Aluminium	73·6	+ 98·8	35·6
MACHINE-BUILDING.			
Lorries	26·9	+ 32·0	36·8
Light automobiles		+ 6·6	43·7
Tractors	10·4	+ 19·8	44·6
Steam engines	29·8	+ 47·5	44·1
Carriages (goods)	2·7 times	+ 134·8	33·3
Harvesters	2·4 ,,	5 times	60·3
BASIC CHEMICALS.			
Sulphuric Acid	23·4	+ 32·9	42·3
Super-Phosphates	34·8	+ 31·4	50·4

A Study of the Elastic Properties of Certain Specimens of Mild Steel

By J. E. HURST

Certain aspects of the elastic properties of mild steel rings are discussed as a result of an investigation into the behaviour of mild steel when heat-treated for special applications.

THE experimental results enumerated in these notes were obtained in the course of an investigation into the behaviour of various materials when treated in various ways for certain special applications. The results relate to certain aspects of the elastic properties of mild steel rings, including the internal stress characteristics, the modulus of elasticity, the permanent set capacity, and the hysteresis. It was considered that certain aspects of these results were of sufficient interest to warrant wider publicity.

The specimens used in this investigation took the form of annular rings 4·71 in. outside diameter, 0·143 in. radial thickness, and 0·250 in. in breadth, machined from a single piece of cold-drawn annealed steel tubing of the following composition :—Comb. carbon, 0·14%; silicon, 0·02%; manganese, 0·52%. Six rings were machined and parted off consecutively from a length of tube. Approximately 3 in. length of tube was used, including the allowances for facing the ends and parting off. Prior to parting off, a line parallel to the axis of the tube was scribed on the machined surface to locate the position for gapping the rings and thus ensure the gaps being cut in the same relative position in each ring. Of the six rings, one was retained for test in the "as received" condition, the remaining five rings were heated in an electric resistance furnace to temperatures of 500°, 600°, 650°, 700°, and 750° C. respectively, followed by quenching in water standing at a temperature of 20° C.

Internal Stress.—The test rings were examined for internal stress, for which purpose the rings were clamped in a vice whilst a gap of an amount in accordance with the requirements of B.S.I. Specification 5004 was cut. The gap thus cut was accurately measured as restrained and also when released from the clamp. The difference between the free gap and the restrained gap is regarded as evidence of internal stresses, and is recorded in inches, positive or negative, according to whether the gap opened out or closed in when released from the restrained position. The actual values of gap movement for each of the specimens in the "as-cast" and treated conditions are recorded below :—

Specimen.	Gap as Cut. Restrained In.	Gap Released. Free Gap In.	Gap Movement. In.
As received	0·34	0·366	+ 0·026
Quenched in water from 500° C. ..	0·34	0·214	— 0·126
,, ,, ,, 600° C. ..	0·34	0·170	— 0·17
,, ,, ,, 650° C. ..	0·34	0·276	— 0·064
,, ,, ,, 700° C. ..	0·34	0·260	— 0·08
,, ,, ,, 750° C. ..	0·34	0·346	+ 0·006

It is surprising to note that the annealed material "as received" shows a substantial gap movement of a positive character—viz., gap-opening. Quenching in water from various temperatures up to 700° C. has the effect of reversing the character of the gap movement to a gap closing, and a very substantial negative movement of the gap, nearly one-eighth of an inch, was observed in the specimen quenched at the lowest temperature of 500° C. Quenching at 600° C. is accompanied by a still further increase in gap movement, still of negative character, and this falls in magnitude at the higher temperatures of 650° and 700° C.

Quenching in water at 750° C. is accompanied by a reversal of the gap movement to positive characteristics—*i.e.*, gap opening of a very small magnitude and the general trend of the gap movement figures lead one to suspect that quenching at some temperatures slightly lower than 750° C., but close to 750° C. would have yielded a condition of no gap movement. However, it is clear that in these specimens quenching in water from a temperature of 750° C. has yielded a material with practically no gap movement; considerably less than in the original annealed condition.

Modulus of Elasticity.—This was determined on the same ring specimens by the method laid down in the above-mentioned B.S.I. Specification, with the following results :—

Specimen.	Modulus of Elasticity. Lb. per Sq. In. $\times 10^6$.	Gap In.	Load. Lb.	Equivalent Rupture Stress. Ton/in.²
As received	30·5	0·314	14·9	17·2
Quenched in water from 500° C.	31·2	0·156	7·4	9·0
,, ,, ,, 600° C.	30·6	0·144	6·8	8·25
,, ,, ,, 650° C.	29·2	0·234	10·7	12·7
,, ,, ,, 700° C.	30·9	0·240	11·5	13·8
,, ,, ,, 750° C.	29·5	0·344	15·7	18·9

The results show slight but irregular variations.

The results of a single set of tests of this nature are hardly sufficient to justify any comment on the irregularity shown. It is essential to point out that owing to the variation in free gap the load required to close the gaps varied in individual specimens by quite a large amount.

This variation in load is equivalent to a very substantial variation in the rupture stress value at which the modulus was determined. The approximate rupture stresses calculated from the relationship given in the B.S.I. Specification are included in the table. These variations are, of course, due to the effect of the gap movement brought about by the release of the internal stresses.

Permanent Set.—The permanent set value is an arbitrary value determined by submitting the test rings to a stress tending to open the gapped rings, applied across a diameter at right angles to that passing through the gap. The differences between the gap before and after removing the applied stress expressed as a percentage of the total change of gap due to the stress is described as the permanent set value. The applied stress used is calculated from the relationship given in the B.S.I. Specification previously mentioned, and in this case a calculated stress of 7 tons per sq. in. equivalent to a modulus of rupture of 11·2 tons per sq. in. was used. The results obtained on the separate specimens are given below.

Specimen.	Original Gap. In.	Gap after Stressing. In.	Gap at 11·2 tons per sq. in.	Permanent Set. %
As received	0·320	0·38	0·60	21·4
Quenched in water from 500° C.	0·156	0·20	0·41	17·3
,, ,, ,, 600° C.	0·144	0·148	0·364	1·8
,, ,, ,, 650° C.	0·234	0·26	0·474	10·8
,, ,, ,, 700° C.	0·244	0·25	0·460	2·78
,, ,, ,, 750° C.	0·344	0·344	0·560	Nil

The high permanent set value of the specimen in the "as received" condition undergoes a reduction in the quenched specimens. Quenched at 500° C. substantial reduction is sustained, but this is exceeded still further in the next specimen. The specimen quenched at 650° C. strangely shows less reduction that the specimens quenched at 600° and 700° C. and in that quenched at 750° C., the permanent set recorded is nil after stressing to the value indicated.

(1) Specimen.	(2) Gap as Cut Restrained In.	(3) Gap Released Free Gap. In.	(4) Gap after Closing once for Modulus of Elasticity. In.	(5) Gap after Opening for Permanent Set. In.
As received	0·34	0·366	0·314	0·38
Quenched 500° C.	0·34	0·214	0·156	0·20
,, 600° C.	0·34	0·170	0·144	0·148
,, 650° C.	0·34	0·276	0·234	0·26
,, 700° C.	0·34	0·260	0·240	0·25
,, 750° C.	0·34	0·346	0·344	0·344

In this connection it is of interest to refer to the changes in gap dimensions sustained by the test rings at various stages of the tests. These are summarised in tabular form above. The original restrained gap when freed undergoes the changes described previously and listed in column (3). After closing the rings once in the determination of the modulus of elasticity, the free gap undergoes a further change, being permanently diminished by quite a substantial percentage in all the specimens except that quenched at 750° C. After subjection to the opening stress applied in the permanent set test, the gaps sustain a substantial permanent opening in all specimens except that quenched in water at 750° C., in which no change is recorded. The specimen quenched at 600° C. also shows very little change in this case.

Hysteresis.—Continuing the study of the change in gap, measurements were taken at intervals of time after stressing for the permanent set test, to the stress value of 11·2 tons per sq. in. Some of the results are tabulated in the next column.

Specimen.	(1) Gap after Permanent Set Test. In.	(2) Gap Measured 10-15 mins. After. (1) In.	Change. In.	(3) Gap Measured 14 days After. (1) In.	Change. In.
As received	0·38	0·378	—0·002	0·376	—0·004
Quenched 500° C.	0·20	0·196	—0·004	0·194	—0·006
,, 600° C.	0·148	0·150	+0·002	0·136	—0·004
,, 650° C.	0·26	0·254	—0·006	0·258	—0·002
,, 700° C.	0·250	0·246	—0·004	0·244	—0·006
,, 750° C.	0·344	0·344	Nil	0·344	Nil

It is evident that quite substantial time elapses before the gap dimensions after stressing reach a degree of stability in all the specimens except that quenched at 750° C. The specimen quenched at 600° C. showed a positive movement, gap opening after a period of 10 to 15 mins., which changed to a negative movement after standing for a period of 14 days. In all other cases the movement was negative, and increased in value after a period of 14 days, with the exception of that quenched at 650° C., which showed a slight recovery after this period.

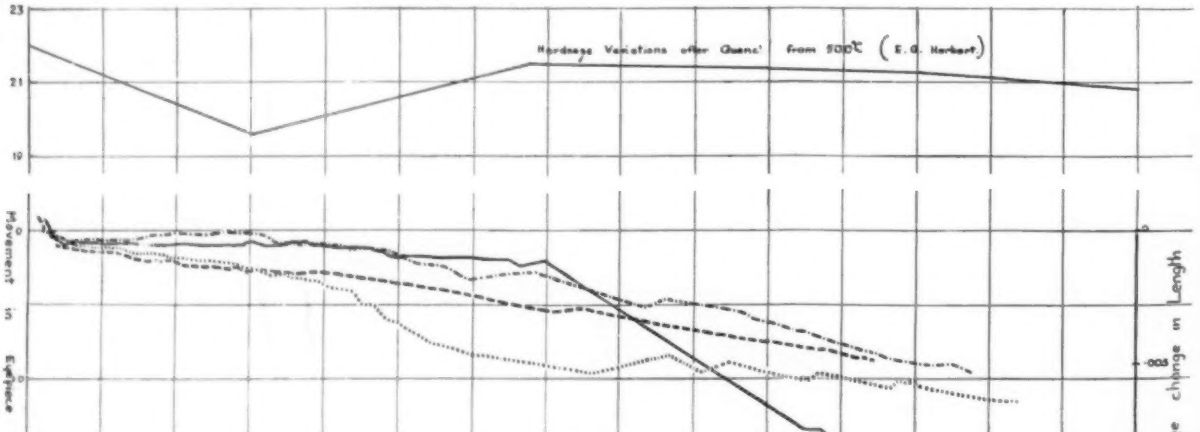
In the specimen of mild steel examined changes in properties are experienced as a result of quenching in water from various temperatures. Quenching in water from a temperature of 750° C. results in almost completely eliminating the signs of internal stress revealed by gap movement. Quenching at intermediate temperatures has altered the character of the internal stress, yielding a negative gap movement. The permanent set value at 11·2 tons per sq. in. rupture modulus, and the hysteresis behaviour of the material after stressing are reduced to nil in the specimens quenched at 750° C.

Length Variation of Nickel on Quenching

By H. GOULBOURNE JONES, M.Sc., A.Inst.P.

The length variations of nickel on quenching have been measured to investigate a possible correlation with hardness changes. The nickel (7.39 cm. long) was annealed in an electrically controlled furnace at 525° C. (approx.), for half an hour and then quenched into cold water. The length changes were next investigated with an optical lever[1] comparing the nickel with a glass prism. The curves, corrected for slight changes in the temperature of the surroundings, indicate that on quenching from 525° C., the nickel decreases in length for 10 minutes; this is followed by a period of little change and finally by a gradual decrease in length. On the same Fig. will be seen the hardness variations quoted from E. G. Herbert[2]. Thus there is little evidence for correlation between length and hardness variations; this supports the precession theory of hardness changes[3]. My thanks are due to Mr. Herbert of Manchester for a nickel rod of the same purity as used in his hardness experiments.

1 *Journ. Sci. Instr.*, p. 325, Oct., 1934.
2 Trans. Inst. Mech. Eng., vol. 124, p. 645, 1933.
3 METALLURGIA, June, 1931.



The Installation and Maintenance of Thermo-Electric Pyrometers—Part 2

By G. H. BARKER

The influence of heat upon the quality and cost of nearly all manufactured products necessitates a thorough understanding of the underlying principles involved and the possibility of controlling the many variable factors affecting the conduct of heating operations. Control of temperature is generally considered the most essential factor, and to facilitate this thermo-electric pyrometers are now almost indispensable. In this article the author discusses important factors in the construction and use of thermo-electric pyrometers.

METAL used for Thermocouples. Although any two dissimilar metals may be used for a thermocouple, certain combinations are unsatisfactory. The desirable properties are (*a*) ability to resist melting, corrosion, oxidation, reduction and crystallisation, (*b*) development of a high e.m.f. (bearing in mind that the largest given by any thermocouple is little more than 50 millivolts), and (*c*) a temperature-e.m.f. relation which is as uniform as possible. In the following table the types of thermocouple metals commonly employed are arranged in order of their temperature-resisting qualities :

Maximum Operating Temperature.		Composition of Thermocouple Wires.	
° F.	° C.	Positive.	Negative.
3,000	1,600	Platinum Rhodium	Pure Platinum
1,800	1,000	Chromel	Alumel
1,400	750	Iron	Constantan

The two general classes of thermocouple are obviously base metal and rare (sometimes called noble) metal. The diameter of the thermocouple wire, apart from determinations arising out of manufacturing convenience and facilities, is determined largely by the service to be given. In the case of base metal thermocouples the most commonly used wire diameter is $\frac{1}{8}$ in. This gives a satisfactory degree of sensitivity and a lengthy useful life ; $\frac{1}{16}$ in. wires are employed where a higher sensitivity is required, for temperatures not exceeding 1,050° C. Thermocouples of this type are normally used for temperatures of oil in pipes, etc., and also almost invariably for the measurement of steam temperatures. Where exceptionally severe conditions are to be withstood, the diameter of the wire used for the thermocouple may rise to $\frac{1}{4}$ in., as for example, in the case of bare thermocouples for immersion into molten metal.

In the case of platinum/platinum-rhodium thermocouples, the most commonly used wire diameter is 0·020 in. for temperatures above 1,320° C., and up to 1,600° C. For temperatures not exceeding 1,440° C., the diameter is usually 0·018 in. Short exposure to higher temperatures than those given above will not necessarily ruin the thermocouple, but will undoubtedly shorten its life and frequently cause it to indicate incorrectly afterwards.

The sensitivity and life of the thermocouple are dependent upon the nature of the protecting sheath employed. The actual thermocouple wires are insulated with porcelain, steatite or other refractory beads and enclosed in a metal or one or more refractory sheaths, or a combination of metal and refractory sheaths depending upon the particular operating conditions.

The point of importance is that the deterioration of thermocouples with age is unavoidable, and the higher the operating temperature and more unfavourable the operating conditions, the more rapid the destruction of the thermocouple. In comparing relative prices for thermocouples, incidentally, prospective users should be sure to consider the corresponding specification as to type, thickness of thermocouple wire, type of protecting sheath, etc., as thermocouples which are apparently " cheap " may prove dear in use through unduly short life.

Protecting Tubes for Thermocouples. Protecting tubes are required to have the following qualities and in deciding upon any pyrometric installation this question must receive careful examination in order that the longest satisfactory life may be obtained from the thermocouples, with the requisite degree of sensitivity :—

(*a*) Resistance to working temperature.
(*b*) Resistance to sudden changes in temperature.
(*c*) Ability to withstand mechanical shock and strain.
(*d*) Ability to withstand the action of oxidising and reducing gases, corrosion by acid, fumes and deposit, action of molten metals, etc.
(*e*) High thermal conductivity—*i.e.*, sensitivity to changes in temperature.

As a rule, one protecting tube is required for the base metal thermocouple, whilst a platinum thermocouple will often require both primary and secondary protecting tubes if its life is to be satisfactory, although a reduction in sensitivity inevitably occurs. The following table lists the commonly used protecting sheaths and gives the maximum working temperature, whilst typical duties are also indicated :—

Type of Tube.	Maximum Temp.	Typical Employment.
Seamless Steel	750° C.	For small diameter thermocouples and where thin wall metallic tubes are required in order to obtain maximum sensitivity.
Wrought Iron	750° C.	Flue gas temperatures, process driers, glass lehrs, etc.
Cast Iron	750° C.	Concentrated mineral acids.
Calorised Iron	850° C.	Molten zinc particularly, but this sheath is often used as a cheap alternative to nickel chromium.
Nickel Chromium	1,000° C.	Heat treatment furnaces : lead baths, etc.
Pure Nickel	1,000° C.	Barium chloride and cyanide baths : also in oxidising atmospheres.
Porcelain	1,250° C.	Where an impervious sheath is needed to protect the thermocouple wire from the effect of gases.

A corresponding list for platinum/platinum-rhodium thermocouples is given below, and these in all cases are of refractory material, due to the high temperatures for which platinum thermocouples must be employed, and because all metals attack platinum :—

Type of Tube.	Maximum Temp.	Quality.
Glazed Porcelain	1,250° C.	Impervious to gases up to figure shown.
Quartz and Silica	1,600° C.	Used for thermocouples subjected to sudden changes in temperature
Vitrified Unglazed Porcelain.	1,600° C.	Used between 1,250° and 1,600° C. normally.

At temperatures within their range, metallic outer sheaths may, of course, be used, and serve to protect the impervious refractory sheath.

The above will be used as single sheaths, or two of them may be employed as primary and secondary sheaths. Where additional protection is required, as in glass melting tanks, where the operating temperature is in the region of 1,350° C., a thermocouple fitted with a vitrified porcelain primary sheath will be additionally protected by insertion in a silica block. This block—taking glass tanks as an example—will be tapered and flanged and passed through a hole in the crown of the furnace. It is supported by the flange and thus able to respond to the natural movement of the crown without damage to the block occurring.

Installation of Thermocouples. It must be borne in mind that the thermocouple is sensitive to the temperature to be measured only at its tip and it will consequently be clear that the degree of immersion must be such as to ensure that the tip reaches a point where the true average temperature can be read.

For example, if the thermocouple is required to pass through a ¼-in. steel wall, having no brick lining, it should project into the hot zone a considerable distance. Where, however, the thermocouple passes through an insulating wall, the true temperature may be obtained with an immersion of as little as two to three inches into the heat. The immersion must be sufficient, however, to ensure the heat conduction up the sheath to the head does not keep the hot junction of the thermocouple at a temperature which is lower than that of the actual furnace. An approximate and popular rule is that the immersion should be equivalent to eight times the diameter of the sheath. A better rule is that the immersion should be such that if increased the reading does not rise appreciably.

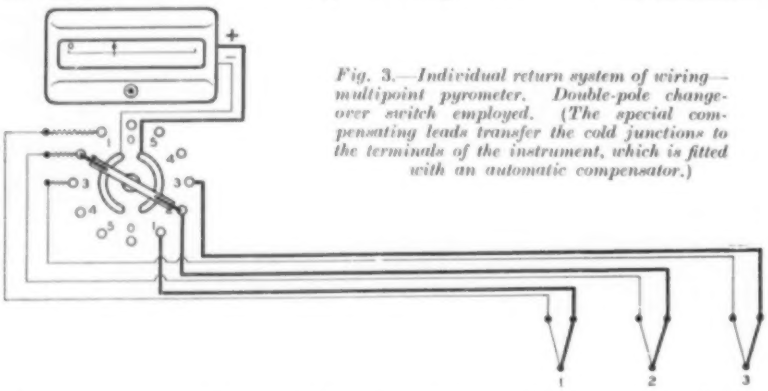


Fig. 3.—Individual return system of wiring—multipoint pyrometer. Double-pole change-over switch employed. (The special compensating leads transfer the cold junctions to the terminals of the instrument, which is fitted with an automatic compensator.)

In the case of heat-treatment furnaces, one should ensure that the tip of the thermocouple is so situated that it measures, as nearly as possible, the temperature of the work in the furnace or, alternatively, give a temperature of which the relation to the actual load temperature has been established. In subsequent operation it should be borne in mind, too, that the tip of the thermocouple is the most sensitive part of the complete furnace, and that the variations indicated will be wider than those of the actual temperature of the load itself because of the mass of the load.

A further point to be borne in mind in dealing with the immersion of thermocouples is to ensure that it is sufficient, but not so excessive as to cause a good deal of overhang, with a consequent tendency for the thermocouple to sag. Moreover, the projection should not be such as to cause fouling with the work inside the furnace with resultant mechanical damage. For all applications, excepting in pipes when the thermocouple is screwed, the thermocouple is fitted with an adjustable flange by which the amount of immersion may be governed. Experimental exploration will decide the best position.

In employing thermocouples having refractory protecting tubes it is essential that these be immersed slowly so that they are warmed up over a period of time. Preferably they should be installed when the furnace or kiln is cold, as sudden or too rapid heating will almost certainly be found to crack the sheath and consequently allow the thermocouple wires to be subjected to the corrosive action of the combustion gases, with a consequently short life. Inspection of the protecting tubes should be frequent, so that those which have become defective can be replaced. Particularly is this important in the case of expensive platinum/platinum-rhodium thermocouples in order that the thermocouple wires may remain unharmed and give the full life of which they are capable. In dealing with these thermocouples, too, it is advisable to replace them when they are showing definite signs of deterioration, as the manufacturer will allow full credit for the platinum which can be recovered.

Running Compensating Leads. Two methods of running the compensating leads between the thermocouples and indicators and recorders are in general use—(*a*) individual return systems, and (*b*) common return systems. The two systems are shown by Figs. 3 and 4. The individual return system is strongly recommended because each thermocouple forms a complete electrical circuit and any danger of shorting between the various thermocouples is eliminated. In the case of the common return system, less wire is needed and erection is usually cheaper, but in multiple installations it may be said to be generally unsatisfactory for the reason that a fault in any circuit affects all of the remaining circuits, and much expensive time waste may result when a fault occurs in tracing and eliminating it. In certain circumstances a common return system may actually cost more than the employment of individual return wires,—*i.e.*, where the points are scattered in such a way that back wiring to pick up a common return becomes extensive.

The compensating leads should be run in conduit in order that a first-class electrical installation be made and adequate mechanical protection of the wiring afforded. Open wiring is not recommended unless local conditions are such as to make running in conduit impracticable—*e.g.*, in wiring widely scattered brick kilns. In such a case the wires should be supported by means of porcelain insulators about every 4 ft., the porcelains being firmly secured.

Joins in wires should be avoided, but where they must be made they must be properly spliced and soldered, rubber taped and finished off with friction tape. As an additional precaution the splices in double conductor leads should be broken as in Fig. 5—*i.e.*, not opposite one another, so that the risk of shorting is still further minimised. The joint must be thoroughly efficient electrically if the service is to be sound.

Where the cost of running compensating leads to a number of thermocouples to a central indicator becomes high, the extension leads may be taken from the thermocouples to a suitably located junction box and ordinary copper lead used to connect this box to the pyrometer-selector switch. An additional length of compensating lead is then used to form an auxiliary thermocouple at the junction box, and is connected in series with the thermocouples through the selector switch. This arrangement is shown by Fig. 6. In this way the pointer of the instrument is caused to deflect in response to temperature variations at the junction box and the thermostatic compensator compensates for any variation in the cold junction of these leads at the indicator.

When the thermocouples have been installed and the wiring completed, care should be taken to see that the plus wire is connected to the plus terminals of the thermocouple and the instrument. If these wires are reversed, it will be clear that no reading will be secured, inasmuch as the pyrometer will endeavour to read backwards. It may be added that it is not infrequently found that when a mistake has been made at the thermocouple end of the circuit and repeated at the instrument end, it is suspected that the mistake is at the instrument, with the result that the leads are then reversed. A reading is secured, and for the time being it is assumed that the installation is

correct. Subsequently, however, it is found that the reading is low and usually the instrument itself is blamed. Actually, the mistake still exists at the thermocouple end of the circuit and the e.m.f. developed by the compensating leads is in oppostiion to that developed by the thermocouple, instead of being supplementary. Such a mistake can involve expensive time waste and annoying service charges.

Resistance of the Thermo-Electric Circuit. In order that the pyrometer may read correctly the temperature of the thermocouple it must be calibrated for the resistance of the circuit, and this includes the thermocouple, the compensating leads and the instrument. All pyrometers are calibrated for the resistance of the circuit before being despatched from the manufacturers' works, and the total resistance will depend upon the range of the instrument, the type of thermocouple being used and the maximum length of compensating leads to be run. A leads-balancing spiral is furnished, so that a final adjustment may be made on site after the installation has been completed and the actual resistance of the circuit measured.

The relation between the e.m.f. of the thermocouple and the e.m.f. indicated by the pyrometer may be determined by the following formula :—

$$Em = \frac{Rm}{Rm + Rt + Rl} \times Et, \text{ where}$$

Et is the millivoltage developed by the thermocouple ; Rm is the resistance of the millivoltmeter ; Rt is the resistance of the thermocouple ; Rl is the resistance of the leads ; Em is the millivolt reading on the instrument.

The value of high instrument resistance, by which is meant the total resistance of the measuring instrument, including the resistance of the moving coil, the "slump"

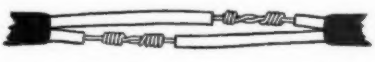


Fig. 5.—Method of jointing thermocouple lead.

resistance and the resistance of the external circuit, lies in the fact that it minimises the effect upon the accuracy of the instrument of changes in atmospheric temperature and in the resistance of the external circuit—the possibility of the latter always being present. The common causes of resistance change are damp, dirt, bad contact at the thermocouple terminals and in the rotary switches used in multiple installations. Such other causes as are beyond control—*e.g.*, unnecessarily large and avoidable atmospheric temperature changes, poor wiring and neglect, have a very much smaller effect upon the accuracy of a high-resistance instrument than upon one of low resistance. A high-resistance instrument is consequently the preferable choice.

As pointed out previously, the accuracy of thermocouples falls off with use. It is consequently the practice of many pyrometer users to adjust the circuit resistance by means of a resistance coil inserted in the thermocouple head, and by this means restore the original accuracy of the system. The practice is a useful one provided it is borne in mind that the feature of interchangeability is lost unless each of the measuring instruments has the same internal resistance. In the case of potentiometric instruments the restance is, in effect, infinite, and this method of adjustment for loss of accuracy through use cannot, of course, be employed.

Checking Installed Pyrometers. In the interests of plant operation and industrial processing, it is essential that means are provided for checking the accuracy of the pyrometric installation, and particularly the condition of the thermocouples, at regular intervals—once a week when extreme accuracy is required, or say, once a month, or every two months in more normal circumstances.

A precision portable potentiometer or millivoltmeter, having a range of 0.50 millivolts is required, together with a set of temperature-millivolt equivalent curves. One platinum thermocouple and one base metal thermocouple, both without protecting tubes, are required as primary and secondary standards, together with a small electric muffle

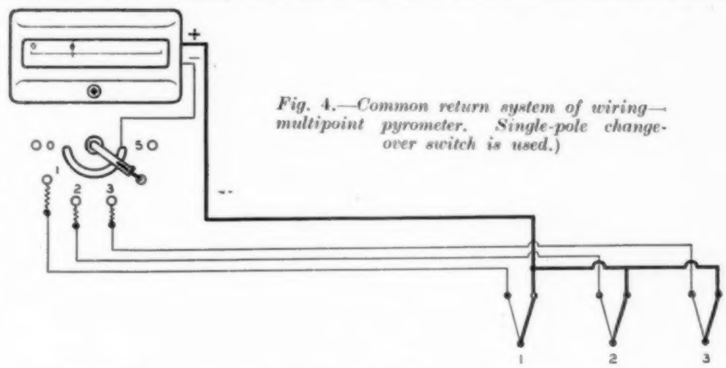


Fig. 4.—Common return system of wiring—multipoint pyrometer. Single-pole change-over switch is used.)

furnace. A battery, with rheostat, is also needed to test indicating and recording pyrometers when disconnected from their thermocouples. A short length of flexible compensating lead is also required.

There are various methods of determing the accuracy of thermocouples and the following may be noted :

(*a*) Freezing point checking.
(*b*) With a muffle furnace.
(*c*) In a metal bath.
(*d*) Checking in situ.

To thoroughly check any complete thermo-electric outfit, a series of freezing point determinations should be made. In practice, however, it will usually be found sufficient to make one such determination which is at or near the normal working temperature. For example, in steel heat treatment, the freezing point of salt (801° C.) is the commonly accepted check point. The salt is raised to a temperature of 850° C., whereupon the thermocouple is inserted

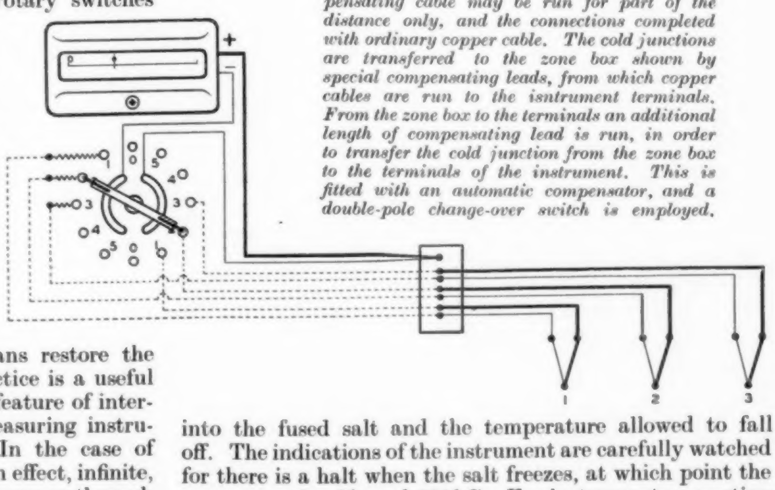


Fig. 6.—Individual return system of wiring, employing copper cables. Where the wiring extends over considerable distances, compensating cable may be run for part of the distance only, and the connections completed with ordinary copper cable. The cold junctions are transferred to the zone box shown by special compensating leads, from which copper cables are run to the isntrument terminals. From the zone box to the terminals an additional length of compensating lead is run, in order to transfer the cold junction from the zone box to the terminals of the instrument. This is fitted with an automatic compensator, and a double-pole change-over switch is employed.

into the fused salt and the temperature allowed to fall off. The indications of the instrument are carefully watched for there is a halt when the salt freezes, at which point the pyrometer should read 801° C. For instruments operating at lower temperatures, lead forms a convenient check-point (327° C.), whilst tin (232° C), zinc (419·5° C.) and aluminium (657° C.) may also be used.

(To be continued.)

The Lomonosov Institute

This Institute is taking a very active part in studying the natural resources of the U.S.S.R., and in this article the nature of its work is reviewed.

THE M.V. Lomonosov Institute of Geological Chemistry, Mineralogy and Crystallography was organised in 1932 by affiliating the mineralogical and geochemical institutes with the Museum of Mineralogy. This affiliation followed the fundamental tendency of recent years to co-ordinate related fields of science to meet the demands of the national economy which called for an all-round study of the natural resources of the country.

The Lomonosov Institute was the first in the U.S.S.R. and one of the first in the world to apply the new geochemical methods to work on special geo-chemical problems. The Institute began to study the distribution and history of chemical elements in the earth's crust. This was considered of particular importance for, at the beginning of the development of geological chemistry, the study of the problems covering the behaviour of the atoms in the earth's crust furnishes material of great theoretical and practical importance, which helps to rationalise prospecting for useful minerals and is the basis of new approaches to technology and metallurgy.

Big problems face the Lomonosov Institute under the present conditions of the Soviet Union. They consist, generally, in the study of the mineral bodies both in earth's crust and in particular in the territory of the U.S.S.R., from the view of their composition, structure, properties, distribution and application.

To facilitate work on individual scientific problems, the Institute is divided into a geo-chemical, mineralogical and crystallographical section and a museum. Academician A. E. Fersman, one of the most outstanding representatives and founder of geological chemistry, is at the head of the Institute.

Solution of complicated problems covering the structure and composition of mineral bodies and the transmutation of atoms of one mineral into the other require modern and very precise apparatus. Therefore, great attention has been paid in recent years to the organisation of an X-ray laboratory for studying the structure of matter and a spectroscope laboratory for precise study of chemical composition, particularly in regard to elements present in negligible quantities. These laboratories, along with the analytical laboratory, as well as that of theoretical geochemistry, are the principal nuclei within which the scientific research work of the Institute is carried on.

The natural resources of the Soviet Union can be studied only by the organisation of numerous expeditions. The latter collect material on geo-chemistry and mineralogy in different parts of the country, and in the winter period this material is thoroughly studied in the laboratories of the Institute.

The industrialisation of the country determined the minerals to be prospected. Regions, where iron, titanium, chromium and tin, and rare metals such as beryllium, tantalum and niobium, and non-ferrous metals such as lead, zinc and mercury exist, were the first to be prospected.

Work was mainly concentrated on the Kola Peninsula, in the Southern Urals and in Central Asia. Exploration of Khibini to discover its mineral resources, was one of the first achievements of the Institute. The systematic study of various Khibini rocks by a group of scientific workers, headed by Academician A. E. Fersman, is well known. As far back as 1920 this group discovered in the Kola Peninsula minerals found nowhere else in the world, such as loparite, lovcharite, fersmanite and others. This great scientific work, carried out under extremely difficult Arctic conditions during the early years of the growing Soviet economy, made it possible to organise the large Khibini Apatite and Nepheline Combine which now employs tens of thousands of workers.

At the time when the apatite deposits were discovered in Khibini in 1926, the region was quite unpopulated, there being only two or three nomad families in the district. At present Khibini is a populous city with large mines and concentration plants.

The Lomonosov Institute still takes a most active part in studying Khibini and other districts of the Kola Peninsula, sending out expeditions, analysing the minerals there and working out new methods for the technical treatment of its raw materials. It has published a number of books dealing with Khibini and is now preparing a large reference work on mineralogy and geological chemistry.

A great deal of work has also been done by the workers of the Institute in the other extreme of the Soviet Union—the far south Central Asia. Here work was done partially by the Institute alone and jointly with other research institutions which took part in the Tajik-Pamir expedition.

As a result of this work many deposits of various useful minerals were discovered. These include the largest deposits of mercury and antimony in the U.S.S.R., a large zone of tin, beryllium and other rare elements. The basic geo-chemical features of the whole of Central Asia have been charted. This will be the subject of a special report at the International Geological Congress to be held in Moscow in 1937.

The Institute also did much research in mineralogy and geo-chemistry in the Urals, where the formation of iron ores, titano-magnetites and chromites was studied. These investigations have thrown light on the conditions of the formation of ores and now forms the basis of projected prospecting and exploitation work.

The work of the Lomonosov Institute in the field of rare elements is of considerable theoretical and practical interest. Rare elements are those which do not occur in large accumulations in the form of minerals in the earth's crust, but are scattered among the other more concentrated elements. Examples are radium, gallium and germanium.

Rare elements, being found in minute quantities, cannot be analysed by ordinary methods, so that little is known of them. Their significance, however, in geo-chemistry is very great, and the Lomonosov Institute has naturally devoted much attention to the investigation of these elements.

For this purpose special laboratories for spectroscopic and X-ray analysis have been created. In these laboratories small quantities of scattered elements in various minerals have been fixed. Much information on the manner in which these elements are distributed has been established. It has been found, for instance, that gallium prefers minerals containing aluminium and zinc, such as mica and zinc sulphide; selenium and tellurium prefer pyrites; indium prefers zinc sulphide. These facts, besides their theoretical interest, are of great practical importance, as they show where various elements are most likely to be found.

New Sheet Rolling Mill at Zaporozhstal Combine

A sheet-rolling mill designed for an annual output of 750,000 tons is to be constructed at the Zaporozhstal Metallurgical Combine, in the Ukraine. The mill is expected to be the largest in Europe and will supply the needs of the auto-tractor industry in steel sheeting. The plant will be almost entirely equipped with Soviet-made machinery.

British Foundrymen Meet at Sheffield

One of the most largely attended Conferences of the Institute of British Foundrymen was held at Sheffield recently and, in this article the many technical papers presented are briefly summarised.

THE Thirty-Second Annual Conference of the Institute of British Foundrymen held at Sheffield on July 2-5, proved to be one of the most successful since the Institute was founded. Especially is this true from a social point of view; the banquet and other functions were very well attended, and the convivial spirit was all that could be desired. Unfortunately the programmes prepared for conferences of this character are usually so comprehensive that little time can be given to technical papers presented. This was particularly noticeable at the present meeting at which several papers were accepted as read and submitted for written discussion, papers which must have involved much work and time on the part of the authors. Apart from this criticism of the arrangements the Conference was in many respects one of the most successful held by this Institute and great credit is due to the Sheffield Branch and to Mr. Makemson, Secretary of the Institute, for the general arrangements.

A business meeting was held as a preliminary to the Conference, at which the report of the Council was presented. It is apparent from this report that the great majority of the members of this organisation can be regarded as active members and despite a slight loss in membership during the period reviewed, this Institute shows distinct signs of increasing vitality. An interesting indication of this vitality was the presentation of the report of the Technical Committee. This Committee embraces Sub-Committees whose activities cover almost every branch of foundry practice. At this business meeting the various officers were elected for the session 1935-36, and Mr. Roy Stubbs, the retiring President, installed Mr. J. E. Hurst as the new President.

The Conference opened on the morning of July 3, at the University of Sheffield by an official welcome in the Mappin Hall by the Lord Mayor, Master Cutler, the Vice-Chancellor of the University, and other distinguished citizens, after which Mr. Hurst delivered his Presidential address in which he dealt with the fundamentals of the heat-treatment of cast-iron.

At this session Sir William Larke, who delivered the first Edward Williams Lecture, referred to the prominent position Sheffield occupied as the centre of metallurgical discovery and development during the present century. Manganese steel, discovered by Sir Robt. Hadfield, had, he said, exercised a profound influence on railway developments, while in the case of tool steels Sheffield was the recognised centre. It is a matter for real gratification, Sir William continued, that every new discovery and achievement opens up an ever wider horizon of unexplored territory. The quest of the scientist and the engineer for further knowledge and achievement can never be ended.

Following this meeting and during the whole of the next morning technical sessions were held at which several papers of more than usual interest were presented which included those presented on behalf of kindred associations in America, France and Germany. The papers embraced a symposium on steel foundry practice, but owing to lack of time only one of the papers in this symposium was discussed. It is not possible to publish the papers here, but the following extracts will indicate the wide range of subjects included in the conference.

REFRACTORIES FOR FOUNDRY USE.

This paper, presented by Mr. W. J. Rees, deals more particularly with the cupola. Two general methods of lining the cupola must be recognised, states the author :—The use of the brick lining and the use of a rammed lining, some granular, plastic or semi-plastic material being rammed around a former. Consideration of the general characteristics of both types of lining, as well as the types of material used for maintenance purpose, such as patching material, show that they all have individual characteristics.

In the modern cupola, very high temperatures are reached and a good deal of mechanical stress is prevalent, due to charging, slag action, etc., and it is desirable, therefore, to select a brick which will resist all these conditions as well as possible. It is shown that from the point of view of resistance to high temperature the brick should be either high in alumina or high in silica. Unfortunately, the silica brick is not particularly suitable for the lining of the cupola because it will not satisfactorily resist very rapid heating or cooling.

Cupola bricks, however, have to resist not only high temperature, but abrasion and mechanical stresses generally and the question to be considered is whether the brick resistant to high temperature will be resistant also to these stresses. One characteristic of bricks made from fireclay is that they tend to lose some of their mechanical strength when raised to high temperatures, and the general trend is for this " refractoriness under load " to decrease slightly with increase in the alumina content of the fireclay.

In discussing rammed linings the author states that when the rammed material is heated it must vitrify enough to produce mechanical strength and must have satisfactory volume stability, as excessive shrinkage may lead to the opening of cracks. Most of the mixtures which are used for ramming cupolas are highly-siliceous usually containing more than 90% of silica. They should not be in the region of, say, 88 to 90% silica, because that is the region of the lowest melting point. They should either be 1 to 3% higher, or 5 to 10% lower and not near the eutectic point.

In general practice the mixtures of this type are made from either a naturally occurring highly siliceous material, or from a mixture of a highly siliceous rock, with just enough clay to give it the necessary workability, but whether a natural material or a synthetic mixture is used, it is desirable to keep well clear of the eutectic composition.

SAND PROBLEMS IN A BRASS FOUNDRY.

The degree of uncertainty and the seeming contradictions which attend the making of brass castings are a direct result of variations in practice and in this paper, Mr. F. Howitt gives an account of some methods which may be adopted to reduce these variations to reasonable proportions. He suggests that if castings be subjected to tests which determine their relative soundness, such as hydraulic pressure or polishing tests, it is found that some are good, some bad, and some indifferent. Thus, there are variations in the process which operate obscurely, and they occur not only between one batch and another, not between one mould and another, but between individual castings in the same mould. Further, if the unsound castings be dissected, and the defects examined, provided that primary precautions have been taken in the melting and casting, it is found that easily the largest number of defects is caused, directly or indirectly, by sand. This is determined by the actual presence of sand in the defects, which is not revealed, in most cases, until it is examined under a moderate power microscope. This sand finds its way into the casting by various ways, and may come from either the core or the mould. Its presence in some cases and

absence in others, and the many forms in which it is manifest, are a sure indication of the variable character of the medium and its manipulation.

The question of the suitability of a sand for a given purpose appears to be a very open one. The only determinate method seems to be the choice of a suitable grain size by experience or usage, and then to find the highest quality sand which approaches it. This problem applies, also, to sands for coremaking, and possibly to a larger degree, despite the fact that the extended use of bondless oil-sands has done much to eliminate the uncertainties attached to this operation. There are cases where it is impracticable to use bondless oil-sand for economic reasons, and in such cases it is still customary in brass-foundries to use spent moulding sand for cores. This practice is unsatisfactory, since sands which are suitable for use under the low gas-pressure conditions which exist in the mould are unsuited to the high-pressure conditions which prevail in the core. Moulding sands for brass are necessarily of fine grain, and therefore of low basic permeability. High permeability is required in cores so that the gas formed during casting may be evacuated at a sufficiently low pressure. Further, the bond in the black sand consists of that proportion of clay and starch or other organic binder which remain from the previous casing operation, and is therefore small. It is not easy to supplement them. Additions of clay reduce the permeability still further and make the core difficult to remove from the casting, whilst additions of organic binder increase the gas evolved. Hence it is necessary to increase the permeability of the sand in some manner, and this is usually accomplished by light ramming.

SYMPOSIUM ON STEEL FOUNDRY PRACTICE.

Steel Castings, with Special Reference to Alloy Steels.

The first of four papers embraced by this symposium was presented by Dr. W. H. Hatfield, and dealt with the range of steels which are now available in cast form. Excellent castings are produced in practically all the steels which have been developed :—the ordinary high-tensile alloy steels, wear-resisting steels, steels of special magnetic properties, corrosion—and acid-resisting steels, heat-resisting steels and many others.

Within the limitations, as regards the space at his disposal, Dr. Hatfield has given some idea of the various special steels applied to foundry practice ; has presented essential data needful for a proper working-out of foundry technique ; and, so far as space allowed, has dealt with the applications and the properties which determine these applications.

Several useful tables have been correlated and are included in the paper. The first giving the properties of the principal groups of heat-resisting steels, their analyses and the heat-treatment to which they are subjected to give service conditions. The second table, which is reproduced here, gives industrial applications of various types of steel castings. Other two tables give physical properties of

TABLE II.

INDUSTRIAL APPLICATIONS OF VARIOUS TYPES OF STEEL CASTINGS.

Class.	Analysis.	Typical Analysis.							Applications.
		C.	Si.	Mn.	Ni.	Cr.	W.	Mo.	
Carbon steel	0·20% C.	0·21	0·27	0·69	—	—	—	—	General structural and engineering mild steel castings.
" "	0·30% C.	0·32	0·24	0·73	—	—	—	—	Higher tensile general carbon steel castings.
" "	0·40% C.	0·39	0·26	0·64	—	—	—	—	General castings possessing wearing surfaces.
" "	0·60% C.	0·62	0·22	0·66	—	—	—	—	Cast steel die-blocks, anvils, hammer tups, cast steel hammer and press tools.
" "	0·75% C.	0·73	0·27	0·69	—	—	—	—	
Alloy steel	1½% Mn (a) 0·25% C. ..	0·23	0·31	1·41	—	—	—	—	Cast steel transmission gears and other parts requiring toughness. Excavator digger teeth and similar details requiring toughness and hardness, to resist a certain amount of abrasion.
	1½% Mn (b) 0·45% C. ..	0·43	0·24	1·36	—	—	—	—	
" "	Ni-Cr	0·36	0·28	0·53	1·62	0·76	—	—	Cast steel gears, tractor excavator, crane, winch parts and other details requiring maximum strength and toughness.
" "	Ni-Cr-Mo	0·32	0·23	0·72	01·87	0·78	—	0·38	
" "	C-Cr	0·43	0·29	0·58	—	0·89	—	—	Specially suitable for cast steel gear blanks, owing to high tensile strength, toughness and good wear-resisting qualities.
Rustless steel	14% Cr. stainless ..	0·29	0·48	0·53	—	13·4	—	—	Cast steel hydraulic and steam plant details. Valve and other items submitted to mildly corrosive conditions.
" "	18% Cr, 2% Ni, stainless.	0·17	0·31	0·57	1·7	17·9	—	—	Highly stressed casting submitted in service to more highly corrosive conditions.
Acid-resisting steel ..	18% Cr, 8% Ni ..	0·10	0·73	0·38	8·2	18·4	0·63	—	Essentially for castings required to resist highly corrosive conditions in chemical plant and for small decorative castings, such as taps, window fasteners, motor-car handles, tramcar fittings.
Heat-resisting steel ..	26% Cr, 10% Ni ..	0·14	1·6	0·49	10·2	25·8	—	—	All classes of furnace details, such, for example, as stove enamelling racks and grids, heat-treatment trays, furnace dampers and furnace doors not submitted to any great stress at high temperatures.
Heat-resisting steel ..	20/25% Cr, 8/12% Ni, 3/4% W.	0·14	1·76	0·43	11·4	23·9	3·2	—	Similar details, such as mechanical stoker parts, rabbles and mechanical pokers required to possess strength as well as resistance to scaling at high temperatures.
" "	30% Cr	0·29	0·97	0·67	—	29·6	—	—	For any of the above items or others where resistance to scaling assumes greater importance than strength at elevated temperatures.
" "	Nichrome (60 : 20 : 20)	0·97	0·84	1·12	63·8	22·1	—	—	For electric heater resistance wires, annealing and case-carburising boxes and other applications requiring maximum heat-resisting properties.
High permeability steel	Low C	0·09	0·32	0·10	—	—	—	—	Alternator stator castings, dynamo rotors, pole pieces, crane magnets and other castings for electrical machinery.
High-temperature steel	Mo (a) 0·20% C...	0·18	0·24	0·63	—	—	—	0·51	For high pressure steam plant ; turbine casings, reciprocating engine, steam chests and other details subjected to stress at the temperature of superheated steam.
	Mo (b) 0·30% C...	0·32	0·36	0·78	—	—	—	0·58	
Shock-resisting steel ..	Mn-Mo	0·25	0·26	1·43	—	—	—	0·54	Essentially to resist stresses and shocks in pile-driving equipment.
Wear-resisting steel ..	C-Cr	0·73	0·34	0·81	—	1·62	—	—	Ball, tube and rod mill grinding plates, impact mill hammers, wash-mill harrows and other castings submitted to wear by attrition.
" " ..	Austenitic Mn	1·07	0·72	12·8	—	—	—	—	Jaw crusher plates, gyratory crusher cones and mantles, crushing rolls, ball, tube and rod mill plates and such applications when the wear takes place by crushing, hammering and pounding.

various types of foundry steels and physical data of foundry steels respectively.

The subject is an extensive one, and in many directions much intensive further investigation is necessary to explore fully the various possibilities of service in the steels now available in cast form. Much additional research is necessary to confirm and to extend the type of data with which the author has endeavoured to deal. So much is this appreciated by the leading firms that advantage is being taken of the possibilities of collective research with the object of extending fundamental knowledge for the industry.

The Joint Committee of the Iron and Steel Institute and the Federation of British Iron and Steel Manufacturers fully merits the support of each constituent firm in the industry in its determined attempt in this field. The need for filling in the gaps in our knowledge as regards the characteristics of the different steels in the liquid state as affected by varying temperature, and the changes in properties which occur at and following upon solidification, is very real, and this paper assists in stressing certain aspects of the matter.

A Note on the Influence of Temperature Gradients in the Production of Steel Castings.

This paper, presented on behalf of the American Foundrymen's Association by Mr. George A. Batty, in the absence of the author was introduced by Mr. V. Delport. In discussing temperature gradients, the author gives two examples of steel castings made under conditions which largely govern American practice. In that country little or no moulding material is used that has the characteristics of either the British " compo " or the Continental European " chamotte," and it is fairly general practice to gate into the lower levels of the mould. Top-pouring such as may be adopted with " compo " moulds is relatively rarely used in American foundries.

The temperature gradients in mould and metal which may be created by top-pouring are more favourable than those attainable by bottom-gating unmanipulated moulds, but are not as favourable as those to be achieved by bottom gating and " reversing " the mould after pouring is completed. The total reversal method is claimed to give the most favourable temperature gradient in both metal and mould. Within limitations prescribed by the available equipment this method is productive of very definite economies, on certain types of castings, and at the same time promotes a degree of integral soundness of structure unattainable by ordinary methods. After describing several examples the author states that with the casting in the reversed position after pouring, the lower levels of the metal are cool, and are in contact with cool mould, while the upper levels, particularly in the head, will be maintained in a fluid condition for a considerable length of time by reason of the heat of the mould with which they are in contact.

The temperature-gradient theory, built upon the practical results arrived at by manipulating moulds after pouring is completed, is applicable with beneficial results to castings made in moulds that cannot be so handled, as it leads the practical foundryman to a more correct appreciation of the functions of gates and heads. A system of step-gating may be considered as being of less efficiency than mould reversal, but more efficient than bottom gating, in promoting soundness of cast structure.

Castings.

Under the above title Messrs. W. Machin and M. C. Oldham present one of the most comprehensive papers on the practical aspects of casting production presented to the Institute and it was regrettable that no time was avaialbe for discussion at the technical session. The authors discuss the whole procedure in order that those connected with the craft will better understand the point raised so that they may be influenced to give closer attention before the pattern is put into the sand with a view to eliminating many of the defects seen in castings.

Every design presents its peculiar problem, more or less, in that the casting has to comply with the exacting demands of modern specification and inspection, relative to the particular service required from it as a finished product. The authors state that progress is being made only by the close co-operation of designer, patternmaker, moulder, coremaker, and metallurgist, and there has been evidence, during recent years, an increasing tendency to establish this collaboration in the foundry. The generally accepted excellence of castings now being produced may be attributed to such co-operation.

Although much of the work discussed in this paper is concerned with steel castings, consideration is given to iron castings in which the alloy cast irons Silal and Nicrosilal are included ; some examples in manganese bronze are also discussed. This paper which embraces 120 pages is well illustrated and since the practical and scientific aspects of castings production are combined so ably we suggest that it should be read by all who desire to possess a sound knowledge of the subject.

Suggestions for Research on Steel Castings.

In a note under the above heading, Professor J. H. Andrew suggests the need for research with a view to systematising the method of feeding and arrangement of heads for steel castings. Although there are thousands of different types of castings he believes that much could be done by experimental research, founded on logical conceptions, to eradicate the troubles that arise through contraction cavities. The discovery of an element that when added to steel would reduce the fluid-solid contraction would be invaluable, and this might well be the subject for investigation. A profitable investigation might well be conducted to determine whether oxygen-free steel is desirable from the standpoint of its strength. The author suggested other fields of possible research, such as facing sands for moulds and the heat-treatment of alloy castings. Generally, he states, a considerable amount of valuable research awaits the investigator who has at his service an equipment capable of dealing with small quantities of metal, up to half a ton, the necessary means of providing suitable moulds and accurate pyrometers.

SOME NOTES ON INGOT MOULDS.

In this paper by Dr. T. Swinden and Mr. G. R. Bolsover the authors state that the annual consumption of ingot moulds is about 100,000 tons, practically the whole of which is in the form of cast iron. None of the special heat-resisting qualities of cast iron have fulfilled the early expectations that they might provide super-quality ingot moulds. There were still differences of opinion whether some of the low-alloyed iron moulds were worth while.

It is necessary to keep in mind that the ingot mould is merely a tool required to give the desired shape to the steel ingot, and its value is to be consiered uder two headings : (*a*) the cost per ton of steel produced, and (*b*) the influence of factors connected with the mould on the quality of the resulting ingot. As regards the cost per ton of ingots, reference was made to a recent paper by Mr. Blakeston, who stated that ingot moulds, bottoms and slag ladles cost from 2s. to 5s. per ton of semi-finished steel. Continental practice apparently shows the cost of moulds to be about 3 per cent. of the total cost of conversion iu the steelmaking shop. The ingot mould costs in the plant of the United Steel Companies, Ltd., with which the authors are associated, varied in 1934 from 9d. to 1s. 7d. per ton according to the type of plant and steel being produced. The cost of bottoms varied from 1½d. to 4½d. per ton.

Referring to the life of moulds on the Continent the authors express the view that moulds continued to be used far beyond the point at which they would be scrapped in this country on account of the influence on the quality of the surface of the resulting ingot. Nevertheless there is

good reason to believe that both from the point of view of the quality of the mould, and the care taken in its use, Continental practice on the whole is somewhat ahead of the average practice in this country. Moulds failed mainly through major crackings rather than from breakdown of the mould surface.

In any consideration of ingot mould costs the authors stressed the fact the quality of the steel must be the first consideration and the value of an improved mould to the steelmaker, judged from the cost-per-ton standpoint, must not be over-exaggerated.

Discussing the paper Dr. Hatfield commented on the paucity of ingot mould manufacturers present. He considered the prices of the ingot costs per ton given in the paper were erroneous, he said, because at his works, where they were engaged on the production of special steels, and could not afford to use a mould that had become depreciated, the cost of their ingot moulds worked out at as much as 5s. to 10s. per ton. He further commented that mould makers are not giving the attention to the subject that they should, nor helping in a practical way. They are not putting down money for research, and they are leaving the steel trade to " carry the baby " the whole time.

STRICKLE MOULDING OF LARGE CASTINGS.

The use of strickles in the making of moulds for large castings is well known whether the moulds are made in dry sand or loam, but the plastic nature of loam renders the method particularly suitable for loam moulds. In this paper by Messrs. H. Fabre and H. Dubois, presented on behalf of the Association Technique de Fonderie, the authors have not attempted to give a definition of the general practice of strickle moulding, but have instanced several cases where the application of the method present characteristic features. The examples have been confined largely to cylindrical work, but to those familiar with loam work it will be appreciated that a considerable range of work, in addition to cylindrical work, lends itself to the use of strickles.

GERMAN PROGRESS IN PISTON RINGS, BRAKE DRUMS AND OTHER AUTOMOBILE CASTINGS.

With the object of obtaining a fine grained, wear-resisting piston ring, the single-ring casting process was introduced in Germany several years ago, and is now universally adopted throughout Germany, states Mr. W. A. Geisler, the author of this, the German exchange, paper. Only very small machining allowance is necessary when the piston rings are made by this process and they can be machined more economically. The determining factor in the choice of this process, however, is the material improvement in quality as compared with those cast from cylinders. Standard single-cast rings are not alloyed, thus they satisfy in every respect the requirements for water-cooled motor-car engines. The steady increase in the efficiency of the engines and the continued development of the Diesel type and of air-cooled engines in general are, however, associated with a considerably higher loading of the piston ring, and every increase in efficiency means a further loading. Here the standard single ring reaches the limit of its capacity : the " efficiency reserve " is exhausted.

To provide higher efficiency reserve the author states the simplest and safest way is by the addition of certain elements as alloys to the piston-ring material and the addition of such elements, in the case of single rings, is possible only to a limited extent. The centrifugal casting process is much more advantageous in the case of alloyed piston rings,

The special elements to be regarded as alloy constituents are those which are not usually contained in grey cast iron, *e.g.*, nickel chromium, molybdenum and vanadium. These elements are added to improve the mileage, to ensure greater tensile strength and, especially, to increase the heat resistance of the casting. A fine-grained and, above all, resistant structure has proved to be necessary and a pearlitic structure alone is not the determining factor. The formation of the pearlite is of importance ; coarsely lamellar pearlite (bush casting) is much less resistant than finely-lamellar pearlite or sorbite, such as is met with in extremely fine-grained cast iron (single or centrifugal casting). The resistance of the carbides to heat can be materially improved by the addition of carbide-forming or carbide promoting elements. These include chromium, molybdenum, vanadium, tungsten, arsenic, antimony and bismuth. In the author's experiments chromium, vanadium and, particularly, molybdenum have so far given the best results. Chromium is the most effective element for this purpose as the addition of only a few tenths per cent. causes a substantial increase in the heat-resistance, whilst at the same time producing a higher degree of hardness and tensile strength. The action of chromium is so sharp, however, that it can only be added, alone, in very small quantities. In most cases chromium is added in combination with nickel, which has the opposite, *i.e.*, a graphite-forming, effect. Additions of molybdenum gave very good results, as this element has not the potency of chromium, but yet promotes in a remarkable degree heat-resistance and tensile strength.

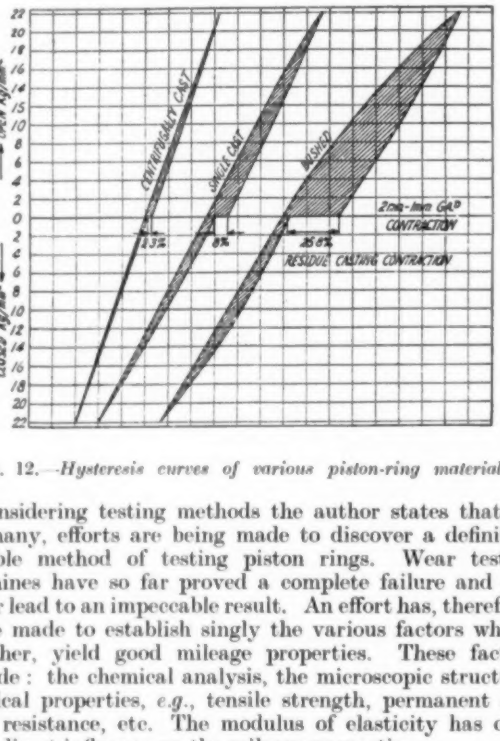


Fig. 12.—Hysteresis curves of various piston-ring materials.

Considering testing methods the author states that, in Germany, efforts are being made to discover a definitely reliable method of testing piston rings. Wear testing machines have so far proved a complete failure and can never lead to an impeccable result. An effort has, therefore, to be made to establish singly the various factors which, together, yield good mileage properties. These factors include : the chemical analysis, the microscopic structure, physical properties, *e.g.*, tensile strength, permanent set, heat resistance, etc. The modulus of elasticity has only an indirect influence on the mileage properties.

On comparing the above factors it is found that the characteristic curve of a piston ring is rather narrowly limited, but an inference may be drawn as to the effectiveness of a piston ring for the purpose required of it. A rapid survey of piston ring material enables us to determine the so-called " piston-ring hysteresis " (Fig. 12). As ordinate, the bending stress per sq. mm. and as abscissa the width of a gap in a piston ring originally free from stresses are taken. The ring is then subjected to pressure, for closing the ends, up to a given maximum pressure, generally 22 kg./mm.² (14 tons per sq. in.), after which the pressure is brought back to zero and the ring is then loaded in the opposite direction—*i.e.*, for opening under the same loading stress, and the pressure again released. The curve does not then return to the original point. The distance from the starting point indicates the extent of the " permanent set," which is best expressed in percentages of the maximum gap width. The area enclosed by the hysteresis curve corresponds to the loss of tension in the ring. The degree of inclination in the curve depends upon

the modulus of elasticity. The higher the modulus the steeper will be the hysteresis curve. The graphs obtained in this investigation afford very valuable indications as to the nature of the material which, in conjunction with the chemical analysis and the examination of the structure yield a complete picture.

A considerable amount of information on brake drums is given in this paper, particularly the combined steel and cast iron drum which are produced in large quantities in Germany. The author states that his experience during the past two years justifies the presumption that this type of drum will find favour in other countries.

RELATIONSHIP IN CAST-IRON TEST RESULTS.

In this paper Mr. G. L. Harbach gives the results of investigations carried out in order to satisfy curiosity regarding queries and popular ideas in connection with cast iron. The paper has been prepared with a view to answering some of the queries and giving, where possible, quantitative values to the influence of various factors, the effects of which are generally appreciated but apt to be over estimated. The author discusses the effect of incorrect size on transverse breaking load, the relation between transverse and tensile strengths, the effect of surface condition on the transverse result, the relation between tops and bottoms of bars cast vertical, the effect of span on modulus of rupture, the relationship between different sizes of test bars, and the effect of section size on strength. He feels there is scope for publicity by manufacturers in the direction of improving the acquaintance of users with the properties of cast iron in general and modern cast irons in particular.

Works Visits

Properly organised works visits cannot fail to be profitable, because discussion which frequently arises in connection with some particular piece of work or operation is beneficial to the host as well as the guest.

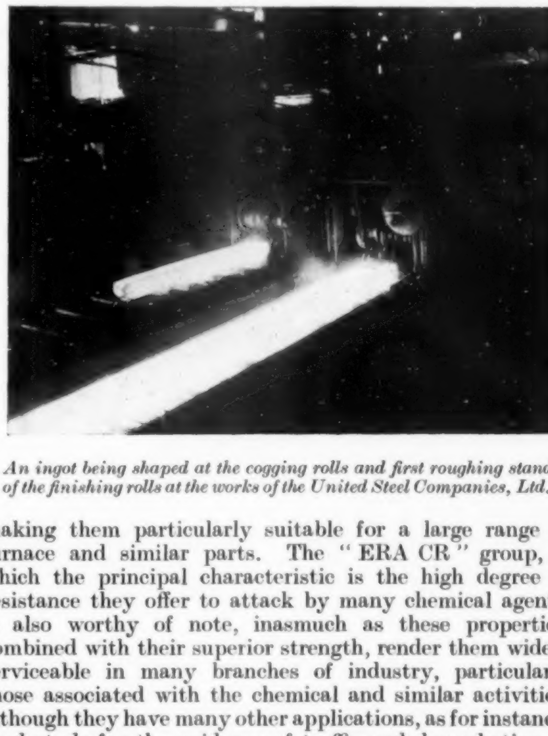
FROM a technical point of view visits to works can frequently be as useful to the members of a technical organisation as the presentation of papers since many aspects of production can be seen at first hand and comments made on the spot which enable discerning visitors to draw useful conclusions. Foundrymen, for instance, find visits to various foundries particularly informative and interesting, at least, the excellent attendances at the various foundries visited by members of the Institute of British Foundrymen attending the recent Conference, seems to indicate their special value. In many works visited, however, the foundry departments represented only a part of the works opened to the visitors.

As Sheffield has been a centre for the production of ferrous materials for so many years the number of works opened to members of this Institute made it difficult to make a choice, since only two visits could be included. Amongst the many works whose directors granted facilities for inspection were Steel, Peech and Tozer, Ltd., a branch of the United Steel Companies, Ltd. Commencing at the Templeboro' Works, the visitors inspected the stockyard and scrap-bundling plant attached to the open-hearth department. In this department, 14 to 80-ton basic open-hearth furnaces are installed with the full complement of charging machines, casting cranes, ingot strippers, etc.

Passing the soaking pits where the ingots are reheated for rolling down into blooms, the visitors inspected the cogging mill which is driven by an electric motor developing 15,500 h.p. The same building houses a continuous billet mill with four stands of 21-in. rolls and six stands of 18-in rolls, a 30-in. roughing mill, and a 21 in. slab mill. It is noteworthy that the average weight of ingots rolled down in these mills at present is approximately 13,000 tons per week. Other departments visited included :—

The exhibits at Hadfields, Ltd., demonstrated that steel castings could be advantageously employed where formerly it had been necessary to use forgings, and despite the fact that many firms now concentrate on the production of steel castings Hadfields' maintain a very high place, in the estimation of users, as steel founders and it is probable that their foundries cover a larger area than those of any other firm of a similar character.

In addition to " ERA " manganese steel, for which this firm has a world-wide reputation, Hadfields's were also pioneers in the introduction and development of a good many other important alloy steels, amongst which may be mentioned the " ERA HR " group of heat-resisting steels, which are characterised by their remarkable non-scaling properties and the high proportion of their original mechanical strength they maintain at high temperatures, thus



An ingot being shaped at the cogging rolls and first roughing stand of the finishing rolls at the works of the United Steel Companies, Ltd.

making them particularly suitable for a large range of furnace and similar parts. The " ERA CR " group, of which the principal characteristic is the high degree of resistance they offer to attack by many chemical agents, is also worthy of note, inasmuch as these properties, combined with their superior strength, render them widely serviceable in many branches of industry, particularly those associated with the chemical and similar activities, although they have many other applications, as for instance, road studs for the guidance of traffic and demarkation of pedestrian crossing lines.

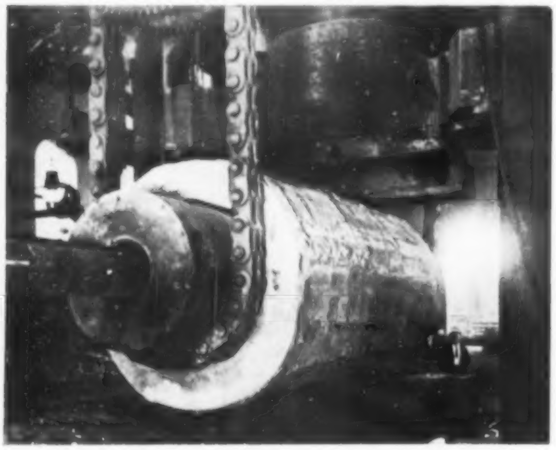
The Sheepbridge Stoker's Centrifugal Castings, Co., Ltd., a subsidiary of Sheepbridge Coal and Iron Co., Ltd., Chesterfield, attracted quite a number of visitors. This firm specialise in the manufacture of centrifugal castings for piston rings, cylinder liners, valve seats and bushes. and special alloy iron castings, sand moulded, for heat, wear and corrosion resistance. Much interest was shown in the production methods employed, particularly in the testing of piston rings.

At the University of Sheffield degree courses in founding have been established to run in conjunction with the ordinary metallurgical degree course and the melting, moulding, and other equipment used in this course was inspected by many members of the Institute who showed considerable enthusiam in the facilities afforded for instruction in this subject.

The plant, which has largely been contributed through the generosity of a number of progressive firms, consist of a 25-cwt. cupolette, a 10-cwt. Bracklesberg rotary furnace, an oil-fired pot furnace for melting steel and a similar one for melting the light alloys, a gas fired brass melting furnace, a 10-cwt. Greaves Etchells electric arc furnace, and a small high-frequency furnace. In addition there is quite a selection of plant for dealing with sand moulds and cores.

An extensive tour of part of the works of the English Steel Corporation, Ltd., was appreciated by a large number of members who were able to see much of the reconstruction scheme undertaken by this firm in 1929. The Cammell Grimesthorpe foundry, which was the first part to be visited, was entirely remodelled a few years ago and has a capacity of 150 to 200 tons of steel castings per week. Additional and up-to-date plant has recently been, and is still being, installed, and considerable interest was taken in the sand reclamation and preparation plant.

This foundry has been responsible for many intricate and heavy castings, the largest single casting ever made weighing just under 150 tons. It comprises a jobbing foundry and a repetition work foundry, and produces castings over a considerable range in weights and sizes for the marine



Forging a hollow vessel with the aid of a 7,000-ton press at the Vickers Works of The English Steel Corporation, Ltd.

electrical, chemical and general engineering industries, including castings for high pressure work, railway rolling stock, dredger and mining spares.

Leaving the foundry the visitors were taken to Vickers Works, where the new Seimens acid open-hearth furnaces were inspected, the party subsequently viewing the medium and heavy forges, and the machine shop. In the heavy-forging industry the experience of the Corporation extends over more than half a century. They are at present manufacturing hollow forged steel vessels up to the largest sizes and weights for use in chemical and oil engineering processes and power plants under conditions of high temperature and pressure, for which class of work they have become an accepted authority, autoclaves, gear wheels and rims, heavy electrical rotors, marine crankshafts, propeller shafting, heavy section rolls for Rolling Mills and other general forgings. The central machine shop with over a mile of bays housing machines which efficiently and economically machine the products of the Corporation. The machines include what is claimed to be the most powerful lathe in this country; in its first run it removed 3½ tons of nickel chrome molybdenum steel in an hour, using Super Cyclone high-speed steel.

A party inspected the large iron foundry of Newton Chambers and Co., Ltd., which is capable of producing castings up to 100 tons in weight. It is equipped with four cupolas each having a capacity of 10 tons per hour. Moulding machines and sand slingers of various types facilitate production. In addition to adequate drying-stove facilities, this foundry also has pipe dipping and testing equipment. Fettling of the castings is carried out in a building attached to the foundry having a capacity of some 20,000 sq. ft. A brass foundry for small non-ferrous castings is attached. The machine and fitting shops have recently been considerably extended and occupy an ara of 70,000 sq. ft. During the last 12 months considerable additions of modern machinery have been made which increase the capacity of this department with a resultant speeding up in production under more economic conditions.

During the last few years most important developments have been in progress at the various Works of The United Steel Companies, Ltd., not the least important being the new high-frequency melting plant, the largest of its kind in Great Britain, which is installed at Messrs. Samuel Fox and Co., Ltd., Stocksbridge. This plant proved a big attraction and a large party took advantage of the opportunity to inspect the Central Research Laboratory which is housed at these Works.

Tin Consumption Analysis

The consumption of tin in manufacture during the first four months of this year totalled 46,400 tons, against 43,800 tons and 35,900 tons respectively in the corresponding months of 1934 and 1933. This year's consumption, according to the June issue of the Bulletin of the International Tin Research and Development Council, issued by the Hague Statistical Office shows an increase of 6% over last year, and the figures show that the increase is very largely due to the expansion of the tin consuming industries in the United States of America.

During the year ended April, 1935, the world used 132,600 tons of tin, against 138,900 tons in the previous year The fact that these figures indicate a decrease of 4½% when world consumption is increasing is explained by the exceptionally heavy imports of tin into the U S.A. during 1933.

From the new tables introduced in this month's Bulletin it may be seen that the Argentine, which imported 63,361 tons of tinplate in 1934 against 47,701 tons in 1933, also consumed 975 tons of pure tin last year. South Africa used 794 tons of tin in 1934 and imported 11,442 tons of tinplate. Egypt and New Zealand used respectively 464 and 195 tons of tin in 1934. All these countries used more tin than in the previous year.

The following table shows the consumption of the principal countries for the year ended April:—

	Year ended April, 1935. tons.	1934. tons.	Increase or decrease %.
U.S.A.	49,220	58,352	— 15·6
United Kingdom	21,391	20,563	+ 4·0
Germany*	10,131	10,686	— 5·2
France*	8,649	9,916	— 12·8
U.S.S.R.	5,503	4,892	+ 12·5
Other Countries	28,253	25,349	+ 11·5
Apparent World Consumption	123,147	129,758	— 5·1
World Consumption in manufacture (approx.)	132,600	138,900	— 4·5
Approx. depletion of consumers' stocks	9,500	9,100	

Consumption in Recent Months

The world's apparent consumption of tin in April, 1935, amounted to 11,343 tons, compared with 10,304 tons in April, 1934. The apparent consumption in the United States in April, 1935, was 4,893 tons against 4,049 tons in April, 1934; in the United Kingdom 2,161 tons against 1,111 tons, and in other countries 4,289 tons against 5,144 tons. In April, 1935, the world production of tinplate amounted to 331,000 tons, compared with 285,000 tons in April last year. The world output of automobiles in April, 1935, was 595,000 vehicles against 445,000 vehicles in April, 1934.

The average price of tin for May, 1935, was £227 16s.

* The tin consumption of the Saar is included with France up to February 18, 1935, and with Germany after that date.

Recent Developments in Materials, Tools and Equipment

A Large Excavator

Designed for the handling of large volumes of over-burden at a single operation, an excavator, working for Messrs. Stewarts and Lloyds, at Corby, is rather exceptional in regard to size. It has a dumping height of 70 feet and a radius of 103 feet so that it can excavate material from a cut 55 feet deep and dump it clear without any rehandling being necessary. The dipper capacity is nine cubic yards, or roughly 12 to 15 tons of earth. The total weight of the excavator, which was manufactured by Messrs. Ransomes and Rapier, Ltd., is about 600 tons.

The dipper of this powerful excavator which measures 9 ft. 9 ins. from latch to tooth point.

The drive is electric, on the Ward-Leonard system, and the operating controls and brakes are so arranged that one man can handle the machine with absolute ease. The main motor generator set is mounted on the tail of the upper frame, it is a five-unit set comprising a 435 k.v.a. synchronous motor, a 275 k.w. hoist generator, two 75 k.w. generators—one each for the crowd and slewing motors and a 20 k.w. 125-volt exciter.

One of the most noteworthy features of the machine is the patented hydraulic levelling mechanism, by means of which the enormous structure can be kept level, whatever the relative height of the tracks. The travelling tracks will be placed on the rough top surface of the ironstone bed but the hydraulic equalizing arrangement is worked so flexibly, simply and easily, that the possibility of distorting the frame is eliminated, as also the waste of power incurred when an excavator is worked on a slope. There is an equalizing cylinder at each corner of the lower frame and the alloy cast steel pistons bear directly on to the top of the trucks. The cylinders can be operated together or independently of each other, and this equalizing device gives all the flexibility of three-point suspension and permits the machine to be operated on or moved over uneven ground without torsional strains in the lower frame.

The hoist drum is geared to the motors by single-reduction double-helical gearing. The hoist rope is triple hitched to the dipper. The dipper arm is of combination steel and wood giving resiliency as well as strength. This inside type of handle is better able to withstand the twisting tendency and shocks from digging in the face and, further, the loads and thrust are taken between the shipper shaft bearings with no overhang. The inside handle also allows the main boom to be of maximum strength, as the width is not restricted to the width of the bucket, as would be the case with outside handles straddling the boom. There is a locking device to the crown motion, worked automatically from the crown controller. Regenerative braking or gravity control can be used at will for the lowering of the dipper, and the slewing mechanism is provided with brakes which are applied automatically when the controller gear returns to the neutral position or when the current is interrupted.

The frames are built up of structural steel plates and rolled sections, but to meet the exacting duty to which a machine of this type is subjected day in and day out, anything from 10 to 24 hours a day, it is essential to use cast steel of the very highest quality and in many points steel of special alloy heat-treated material for all the gearing, dipper handle racks, the dipper itself, slew rack and support castings. The dipper front, for instance, is of manganese cast steel, as are also the dipper teeth, dipper handle racks and the crowding pinions. An idea of the size of some of the castings, the bulk of which were made by Messrs. Edgar Allen and Co., Ltd., is obtained from the accompanying illustration of the dipper, the front of which measures 9ft. 9in. from latch to tooth point. The back of the dipper is an alloy steel casting and a man can stand inside the dipper when it is assembled. Alloy steel castings were also used for such vital points as the boom foot knuckle casting and the massive boom foot socket casting placed at the front of the rotating frame.

The whole machine has been laid out to provide the greatest possible accessibility and ease and speed of handling and, at the same time, has been constructed for continuous duty. It is reputed to be the biggest shovel yet built in Europe.

Temperature Control Instruments

In view of the increasing attention being devoted to accurate heat treatment of metals and alloys, developments in suitable equipment have considerable importance. In this connection a noteworthy example is the new Electroflo "Longscale" control pyrometer. The patent mechanical selector mechanism used for the past six years in Electroflo control pyrometers, which has been so successful, is retained without change in this new pyrometer.

The advantages claimed for this new instrument include neater appearance and the facility for flush-panel mounting, whilst the longer scale enables readings to be obtained with higher precision than was heretofore possible. The accuracy of control is greater for the same reason, and because the characteristics of the movement—torque-weight ratio, resistance in ohms per millivolt, etc., have been improved compared with the already high standard set by the original shorter scale model.

The Electroflo patent broken thermocouple safety device, which protects the furnace and its contents against failure of the thermocouple or its circuit is, in the new "Longscale" instrument, housed inside the main casing. The battery is, of course, external, but the coils of the Wheatstone Bridge and other parts are completely enclosed in the case. The two push buttons visible on the lower left hand side of the instrument, see Fig. 1, are provided for checking the setting of the device and testing its operation respectively. By depressing both buttons the zero of the instrument can be tested without the necessity for disconnecting the thermocouple.

Controllers, such as the one described above can be used to control small electric furnaces up to about 12 kilowatts

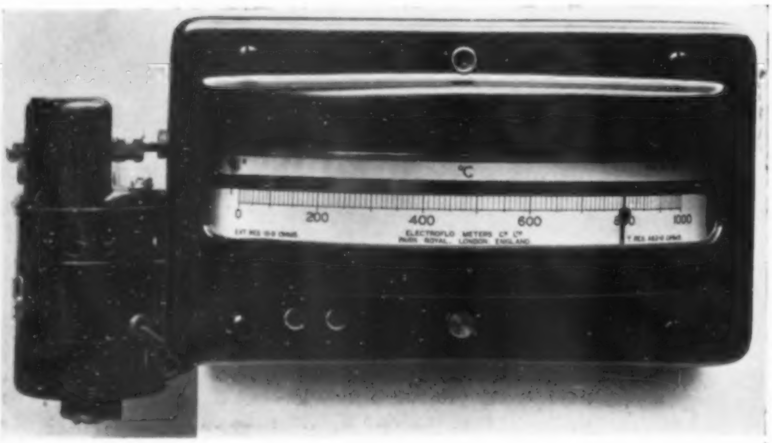


Fig. 1.—New "Longscale" control pyrometer.

capacity directly. For large size electric furnaces intermediary contactors are required, but for gas-fired furnaces, oil-fired furnaces, steam-heated plants, etc., motor-driven regulators are required to actuate the valves and/or dampers. Occasionally motor-operated valves or solenoid valves are used, but the most satisfactory arrangement is undoubtedly to use a motor-operated regulator connected to the valves and/or dampers by means of adjustable links.

Small regulators, with a torque of 200 to 300 lbs. inches, are commonly employed, but for large furnaces, where heavy dampers, air slides, or large operating valves are used, more powerful equipment is obviously necessary. The new regulator shown in Fig. 2 develops a torque of no less than 2,400 lbs. inches—sufficient for the largest of industrial furnaces, and its substantial construction can be appreciated from the photograph. As with Electroflo control pyrometers, these regulators are made in two distinct types: the two-position and three-position. In the former the operating lever is arranged to move between two limiting positions—maximum and minimum—whilst in the latter there is also a central or mid-position. In each case the positions are readily adjustable by means of the limit switches provided.

On coal-fired furnaces, boilers and certain other plant,

Fig. 3.—New "Longscale" multipoint indicating pyrometer.

fully automatic control is not possible, and indicating pyrometers must then be used instead of control equipment. Fig. 2 shows one of the new Electroflo "Longscale" multipoint indicating pyrometers. Apart from the extremely high internal resistance of over 20 ohms per millivolt these instruments are distinguished by their substantial construction and convenient arrangement. The long scale is, of course, the most striking characteristic, and its advantages from the point of view of legibility can be readily appreciated. On wall mounting models the switch box is hinged in order to facilitate making connections, but the instruments can also be flush-panel mounted where this method is preferred.

Fig. 2.—New small regulator showing substantial constructional features.

Canada's Mica Industry Shows Marked Progress

REGISTERING a gain of close to 160% over the previous year, the value of Canadian mica exports rose from $46,200 in 1933 to $117,800 in 1934. The larger portion of the 1934 shipments, consisting entirely of amber mica, the only type produced in Canada, was consigned to the United Kingdom. This is in marked contrast to the practice of earlier years, when the United States was the principal consumer. According to the Department of Mines at Ottawa, there was a good demand throughout the year for trimmed sheet in all sizes.

The rise in exports reflects a continuation of a pronounced upward trend in the industry since early in 1933, and constitutes a strong bid by Canada to regain her former position as the world's chief source of amber mica. This position was lost some years ago following the exploitation of deposits in Madagascar, from which source competition became so keen that practically all of the Canadian mines were forced to close down, or to severely curtail operations. Resumption of activities is attributed largely to the marked decline in mica output from the island in recent years.

In contrast with earlier years, when the supply was derived from a large number of scattered properties, many of them worked by farmers and small owners in the "off" season, production in Canada is now pretty well in the hands of a few firms, most of them operating their own mines. Such concentration operates to the advantage of the industry, since it tends to assure proper attention to trimming and grading, and to guarantee to buyers that contract shipments will be in accordance with their requirements.

Material Problems in the German Chemical Industry

Difficulties associated with the supply of certain national materials for use in the manufacture of chemical plant and appliances were discussed at the recent annual general meeting of the German Chemical Society at Konigsberg. It is apparent from the various types of materials discussed that efforts are being made to develop home supplies. In this article extracts of some of the discussions are given.

IN a theoretical world in which all countries buy in the cheapest markets and sell where best prices are obtained for their commodities, unhampered by excessive tariffs and other trade restrictions, a lack of balance between two individual countries would deserve little special comment. Triangular relationships, for instance, would accurately and quickly offset such balances. In the present phase of extreme nationalism, however, the problem of international trade is not so readily solved. Under present conditions nations place considerable importance upon particular activities, and each endeavours, as far as possible, to meet the needs of those activities from its own resources. At the recent meeting of the German Society for the manufacture of chemical plant, for instance, the advisability of using German materials was stressed.

Many problems are raised by the desire to use only home supplies, as Dr. E. Rabald pointed out in a lecture on modern material problems in the chemical industry. The question, What are German materials, he stated, cannot be answered by just saying, materials from German raw materials, manufactured in Germany, because an essential factor, which is very often a decisive factor for materials used in chemical science, namely, the work undertaken for the manufacture of these highly technical materials would not be taken into consideration. We must differentiate between materials which are produced from German raw materials, those which are obtained from foreign raw materials, and those we receive from abroad as materials which are capable of being worked up.

It is chiefly non-ferrous metals which are essential in chemical apparatus. From a series of informative diagrams, Dr. Rabald endeavoured, among other things, to solve the question of what could be saved by exchange material in the German foreign-exchange balance, and in which industries or to which products the individually quoted non-ferrous metals could be used. He expressed the subdivision of materials mentioned, in another form, by arranging materials with little or no foreign exchange expenditure, which are designated as exchange materials—those with medium foreign exchange expenditure, which he called economy material of the second class, and those of high foreign exchange expenditure, which are equal to economy material of the first class.

In the course of his explanations, he made suggestions likely to save the home material and further to improve the trade balance. The following measures appear to be possible :—

1.—A greater application of exchange materials.

2.—Economy and protective measures, as, for example, the reobtaining of used material, relevant production, selection and working up, protective measures of a physical and chemical nature in the various possible ways.

In conclusion, Dr. Rabald went deeply into details and spoke of the problems which present themselves with material, corrosion research, and with regard to the improvement of the methods for obtaining metals. He confined himself to a rough outline of the problems of material and corrosion research. For example, it was necessary further to test the influence of small admixtures upon the physical and chemical qualities of the materials, as, particularly in this sphere, quite good results had already been achieved. Also the appearance of corrosion fatigue needs some further elucidation, while other large fields still remain to be explored in which great problems are to be solved by analytical chemists, physicists, engineers and, in fact, by all those who are interested in the material problem and in joint co-operation.

Aluminium from Clay

According to H. Rohrig successful experiments in the production of aluminium from clay have resulted in a yield of metal similar in quality to that obtained from bauxite. The improvement in the degree of purity of aluminium, he states, has made extraordinary progress in the last decade. The most important improvement is the increase of the average aluminium content in the metal obtained by the usual electrolytic refining process. Here, he claims, Germany is leading. Furthermore, to the analytical chemist and for construction of apparatus, the results of the refining processes, with the help of which metal of a purity of 99.995 can be obtained, are very remarkable.

The chemical stability of aluminium is not influenced by the individual admixtures in the same way, only a few result in a direct improvement. Some contribute indirectly to the increase of the power of resistance by effecting a finer distribution of the detrimental admixtures. The determining factor for the capacity of resistance against chemical influences is the physical state of the materials of construction. At high temperatures, intermediate and soft annealing pure aluminium sheets are always superior as regards durability. The suitability of aluminium for the construction of even complicated apparatus is furthermore dependent upon its good workability and weldability. The carrying out of the welding seams and their correct after-treatment have, as recent experiments have shown, a decisive influence upon their durability. Materials which corrode aluminium can be rendered harmless in a sometimes surprising way by small admixtures of inhibitors.

Iron Castings for Chemical Plant

Much work has been done in the development of suitable cast-iron materials for the construction of chemical plant. This was emphasised by Dr. H. Jungbluth, who stated that there are, broadly, four types of cast iron suitable for chemical plant. In the first type the main constituent of the iron is silicon, the amount ranging from 14 to 16%. This covers a number of proprietary cast-iron alloys such as Thermisilid, Tantiron, Wegucit, Sisteisen, Duriron, etc. These alloys are resistant to many corrosive media and are durable ; they are relatively cheap and cast well, but are not easily machined while the mechanical properties are relatively low. More favourable mechanical qualities are achieved by alloys of the iron-chromium type containing about 13 to 15% chromium, but it is necessary to differentiate between those of the steel type and those of cast iron. The steel-like corrosion resisting alloys of the high-chromium type, however, have not succeeded so well as the nickel-chromium alloys, while the cast-iron alloys have only been successful to a limited extent.

Dr. Jungbluth states that the chromium-nickel alloys are superior, but it is necessary to distinguish between the steel and cast-iron types ; he referred to the martensitic steels containing 18% chromium, and to the 8-18 nickel-chromium austenitic steels, in comparison with the material containing about 1.5% carbon, 6% nickel and 25% chromium. In addition to the alloys already mentioned, pure cast alloys were developed in America on the basis of iron-nickel-copper. Originally this alloy was obtained by mixing grey cast iron with Monel metal in the proportion of two to one. Those were the so-called Nimol cast irons,

Since then they have been further developed into "Ni-resist" by the addition of further alloy elements, so that they are now round about the limits of 2.0, 4.0% C, 5.0 to 35.0% Ni, 2.0 to 8.0% Cr, 2.2 to 16.0% Cu, 3.0 to 10.0% Mn, 3.0% Al; the chromium always being of a lower percentage than nickel. These materials are considered to be excellent casting alloys and compete, in their capacity of resisting acids, with bronzes, for which they, in some ways, offer a complete substitute.

Testing Thin Sheet Metals

With the increasing use of thinner sheet metals in many industrial applications, questions of proper methods of determining their physical characteristics and the significance of such tests have become increasingly important. These problems have been receiving the attention of an A.S.T.M. Committee on Testing Thin Sheet Metals. Two of these problems which have occupied the Committee's attention include studies of methods of hardness testing of very thin sheet metals, and the obtaining of information as to the scope and usefulness of the various mechanical tests.

The indentation hardness studies have resulted in recommendations respecting details of procedure in determining the Rockwell hardness of thin sheet metallic materials, and these were approved for submission to the Committee on Indentation Hardness. In order to encourage the informal presentation of information concerning the practical utilisation of tests applied to metals in sheet form, a questionnaire was prepared and distributed to a large number of laboratories, manufacturers, users and others interested in the testing of these materials. The information thus far obtained has indicated that various tests, including tension, several types of indentation hardness, cold bend, cupping, fatigue, shear or punching, impact, metallographic, creep, corrosion, embrittlement, etc., are now being used for determining the properties of sheet metals. The data and information resulting from this questionnaire will be invaluable to the Committee in formulating standards for the testing of thin sheet metals.

Preparations are now being made by the Committee for a round table discussion of ductility testing of sheet metals, which is also to be held during the annual meeting. This will involve largely the so-called "cupping tests," and this work will be carried on in co-operation with the section on Bend Testing. This round table discussion will be the second arranged by this Committee.

The Sullivan Mine, British Columbia

According to Mr. S. G. Blaylock, Vice-President and General Manager of the Consolidated Mining and Smelting Co. of Canada, Ltd., the Sullivan mine, near Kimberley, British Columbia, provides most of the necessary ore for a daily production of 800 tons of lead and zinc—representing over 10% of the world output of these metals. The ore, however, is extremely complex, and in addition to its lead and zinc content there is recovered therefrom silver and minor metals, such as bismuth and cadmium, together with large percentages of sulphur and iron. Much of the sulphur is now being converted into sulphuric acid utilised in the manufacture of high-grade fertiliser. Extensive tests by the company have shown that the yield per acre of wheat on the Canadian prairies can be increased 25 to 30% by the use of this fertiliser, whilst at the same time the grade of the grain is much improved and the time of ripening advanced by ten days. Mr. Blaylock continued: "The discovery of Marquis wheat, which advanced the wheat crop five days, has netted hundreds of millions of dollars for the prairie farmers. Consider, then, what ten days in addition to this and six more bushels per acre, will do for the prairie wheat crop. In addition, he pointed out that a great iron mine is gradually being formed on the surface near the Sullivan mine. Every day about 2,000 tons of pyrite and pyrrhotite are separated from the Sullivan ore, and stock-piled for future use.

De-Tarring of Coke Oven Gas

With regard to the series of "Memorandum" dealing with fuel technology issued by the Utilisation of Coal Committee of the Institution of Mining Engineers, considerable interest attaches to the latest of these (No. 17) entitled "The Electrostatic De-Tarring of Coke Oven Gas," which gives a good description of the advantages of this efficient method of removing tar particles.

In general the older types of "impact" tar separator, such as the "Pelouze-Audouin" and the "Otto," even in conjunction with present day high-speed exhausters, cannot separate all the finely divided tar particles in the form of "mist" or "fog" in the gas. Consequently troubles are caused with such inefficiently cleaned gas by deposition of tar in pipes, boosters, burner nozzles, and other equipment. The Memorandum states that electrostatic methods will operate at about 99% efficiency. This is particularly important for modern automatically-controlled gas burners with fine nozzles, which cannot function unless an absolutely clean gas is used.

It will be remembered the pioneer of electrostatic dust and tar separation is Sir Oliver Lodge, and the modern "Lodge-Cottrell" equipment represents the combined work, with pooling of all the patents and experience, of Sir Oliver Lodge, Dr. Cottrell in the United States and Dr. Moller in Germany. A considerable number of plants of this make are now operating in Great Britain and the United States for coke-oven gas, and the standard performance guarantee is 99% tar removal, plus or minus 1%, involving also the removal of water particles. The back pressure is negligible, about $\frac{1}{8}$ in., and the consequent saving in fan power, compared with other methods, is usually more than the total power required to operate the electrostatic method. Another point, not mentioned in "Memorandum No. 17" is that the complete removal of the tar prevents thickening of the gas oil used in scrubbing for light oil, this alone representing a considerable economy, while also the tar separated by electrostatic methods shows no trace of emulsification and separates from water almost immediately.

Similar detarrers are installed in towns gas works to clean coal gas and carburetted water gas, and an outstanding feature is the reduction of the costs of purification. As a result, the tar "poisoning" of the iron oxide beds is avoided, fresh oixde is less frequently needed, and the spent oxide commands a higher price.

The basic principle of electrostatic precipitation is the use of plates or pipes, constituting a series of earthed collector electrodes. In the narrow speaces between these plates, or in the pipes, hang wires or rods with numerous points, forming discharge electrodes, which are coupled to high tension direct current supply generally at 60,000 to 70,000 volts stepped up from A/C so that corona discharge takes place. As a result the dust particles in the gases which pass through the ducts or pipes are electrified, receiving a negative charge, and repelled against the earthed collector electrodes, which may be equipped with motor-driven rapping hammers, when dry dust has to be brought down.

The Chromium Mining and Smelting Corporation, Ltd., announces the purchase of the plant of Superior Alloys, Ltd., at Sault Ste. Marie, Ontario, which will be utilised for the smelting and refining of chromium ores from the Corporation's mine at Collins, in the Obonga Lake district of Ontario. In addition to the production of chromium, the plant will continue its present output of ferro-silicon, for which there is a market in the local steel plant. The initial output of metals, including by-products, is expected to approximate 500 tons monthly. The plant at present has three furnaces, and a fourth will be added by the removal of the Corporation's furnaces from Niagara Falls, New York. The Corporation is already assured of a market for its products in Great Britain, whilst there is available at railhead several months' supply of ore.

The National Physical Laboratory

Apart from work of a fundamental character, the investigations carried out are designed to facilitate the progress of Industry.

THE work of the National Physical Laboratory is primarily concerned with new problems which are continually being presented, in establishing facts which can be applied to industry, and in facilitating the progress of industry by assisting in adding to knowledge of materials and structures. A heavy responsibility rests upon its work in initiating and carrying out research in such a manner that the latest scientific discoveries can be applied to industry with the least possible delay. It has been said that research is essentially exploration, for which the investigator has to fashion his own specially sensitive and delicate metal instruments. It is like trying to reach the centre of a maze, which can sometimes be found by a happy accident, or by sheer good luck, but it is most assured when the side tracks which so often appear to be the main path, are systematically explored and labelled for future use so as to prevent confusion. Even when the main path has been determined there is a difficulty in persuading others to use it and thus give it practical value.

This is the work done in the National Physical Laboratory which consists of seven technical departments—physics electricity, metrology, engineering, metallurgy, aerodynamics, and National tank—and its staff numbers well over 600. The work covers a very wide field, including all branches of physics, electricity and magnetism, wireless work, engineering, metallurgy and chemistry, aeronautics, and ship design in relation to form and propulsion, and some of the work done and in progress proved most interesting and informative on the occasion of the inspection by the General Board.

It is not possible here to review all the work done and in progress, but reference may be made to fluid pressure cupping tests on sheet metal, which have been developed in the engineering department. At present it is not possible to specify exactly the mechanical properties of sheet metals used for deep drawing purposes, but there is no doubt that the plastic behaviour of the material is a most important factor. To assist in this matter this fluid pressure cupping test has been developed whereby it is possible to obtain complete load-deformation curves of the plastic distortion of metal sheets. Another problem which has involved much work concerns thin sheet metal. When a panel of thin-sheet material of which the edges are supported or clamped is subjected to shearing and/or compressive loads in the plane of the sheet, its behaviour may be considerably affected by the occurrence of buckling. In all cases buckling causes an immediate reduction in stiffness ; for instance, in the case of a plane rectangular panel with simply supported edges loaded in compression parallel to the longer pair of edges, the ratio of the rate of increase of strain to the rate of increase of load is three times as great after buckling as before. Panels curved about an axis parallel to the direction of compression behave similarly, although the load at which buckling occurs is increased by the curvature of the sheet ; but in this case an actual reduction of load may also occur at buckling.

Considerable attention has been devoted to the study of the behaviour of metals under cyclical stresses or fatigue, employing simple stress systems, such as direct flexural or torsional stresses, but practically no information exists concerning the effects of *combined* fatigue stress. One common stress system is combined bending and torsion, both alternating (*e.g.*, in crankshafts), and for the determination of the strength of materials under this system a new type of machine has been designed. Three machines constructed have been to this design, and tests are at present being made on a representative range of plain and alloy steels, and on cast crankshaft materials.

In the Metallurgical department magnesium alloys are being intensively investigated. The object is to develop light alloys stronger than those at present available, for use both at ordinary and elevated temperatures. There is a demand among aircraft constructors for improved magnesium alloys. Particular attention is being given to discover metals which are soluble in solid magnesium, and which are more soluble at elevated than at ordinary temperatures, so that the strength of the alloys can be improved by heat-treatment. This involves the study of microstructure and constitution, as well as of rolling and mechanical properties. This work is made more difficult because many magnesium alloys cannot readily be forged and rolled. For this reason it has been necessary to evolve methods of hot-working the cast metal. Special attention has been given to the effect of slow pressing and it has been found possible to work alloys by this means which are difficult or impossible to roll satisfactorily. In some cases material which has first been pressed can then be rolled more easily. In this connection a new experimental mill for slow-speed rolling has been installed.

The work of the Laboratory, not only because of the fundamental work done, but because of the subsequent investigations is designed to provide the knowledge which enables discoveries to be applied in industry with the least possible delay.

A New British Chemical Standard

In view of the increasing interest in alloy cast irons British Chemical Standards Headquarters is now issuing the first of a series of irons containing special elements.

This standard analysed sample is more or less typical of the type used for the production of specially hard cast irons by alloying and heat treatment, and should be useful to chemists wishing for more information about the determination of Ni, Cr, and Mo, and the effect of these elements on the determination of the ordinary constituents.

The standard turnings have been carefully analysed as usual by a number of experienced chemists representing the different interests involved—*viz.*, the B.C.I.R.A., Independent Analysts, a Government Department, a ferro alloy manufacture, also producers and users of alloy cast irons. The constituents standardised are as follows:—

	%		%
Total carbon	2·79	Sulphur	0·068
Graphitic carbon	1·99	Phosphorus	0·348
Combined carbon	0·80	Nickel	1·71
Silicon	1·64	Chromium	0·405
Manganese	0·93	Molybdenum	0·36

It is believed that this is the only standard of its kind in Great Britain and is, therefore, likely to be of national interest to both independent chemists, Government chemists, and works chemists associated with the manufacture and use of alloy irons, including the aviation, motor, and engineering industries.

The standard is issued in bottles containing 500 grms. 100 grms., 50 grms., and 25 grms., at a price which it is estimated will eventually cover the cost. Each bottle is provided with a certificate showing the analysis of each chemist, together with an outline of the methods used ; in particular the method for determining molybdenum has been dealt with at some length and will no doubt be of interest.

The standard may be obtained from British Chemical Standards Headquarters (Ridsdale and Co.), 3, Wilson Street, Middlesbrough, or from any of the laboratory furnishers.

Reviews of Current Literature.

The Physical Chemistry of Steel Making

This book, which gives the results of a continuation of a programme on the study of the physical chemistry of steel-making commenced in 1926 by the Metallurgical Advisory Board to the Carnegie Institute of Technology, comprises a number of bulletins dealing with specific aspects of the subject. The first part of the work included the study of non-metallic inclusions, their nature, properties, method of determination and elimination. The results of this study by D. C. H. Hertz, Junr. and his associates have been published from time to time in a series of bulletins. The new programme, which commenced in 1931 and was continued for about three years, included a study of the refining of steel in open-hearth furnaces with special emphasis on the control of the oxides in slag and the relationship between slag oxidation and metal oxidation; strong deoxidizers; elimination of non-metallic matter; gases in steel; quicker methods of determining inclusions, and the influence of these inclusions on the physical properties of the finished steel, and allied problems. The plant work on control of slag oxidation was carried on at convenient locations on a number of grades of steel. Bulletins have been issued from time to time so that those interested would be promptly informed of results. The bulletins published in 1934 contain a summary of the accomplishments of the programme.

The investigations described in this book are given in the form of bulletins, the first dealing with the effect of deoxidation on the rate of ferrite formation in plain carbon steels. It is noteworthy in this investigationthat the authors have developed a method of determining the specific reactivity of any steel during ferrite formation and the results are given for coarse and fine grained plain carbon steels. It is shown that the specific reactivity is higher for a certain type of aluminium killed steel and that it decreases with increasing manganese content. That the grain size of plain carbon steels is profoundly affected by the method of deoxidation used is shown by the investigation on the effect of deoxidation on grain size and grain growth in plain carbon steels.

Probably the most important part of this book is the bulletin which describes in abstract the work done on the deoxidation of steel by investigators of this co-operative project. The reactions of deoxidation are described and the best values of the deoxidation constants given. The theory of inclusion elimination is reviewed and the slag systems involved in deoxidation are shown, as are the types of inclusions formed by the three deoxidisers, manganese, silicon and aluminium, singly and in various combinations. The deoxidation of open-hearth steel is discussed from the standpoint of steel cleanliness and deoxidiser efficiency, and allied subjects, such as rephosphorisation after deoxidation, are brought to the attention of the reader; a brief review of the various methods of determining inclusions is also presented.

In addition to the effect of deoxidation on grain size and grain growth, its effects on hardenability, impact strength at low temperatures, and ageing have been investigated and the results are given. It will be appreciated that this book gives the essential results of a very comprehensive programme of study, and it is claimed that practical tests on acid and basic open-hearth heats show in general a distinct improvement in quality and fewer rejections where the results of the various investigations have been put into practice.

This book is a valuable addition to the technical literature on the manufacture of steel and the information it contains should have a considerable influence in improving the quality of steels when the principles deduced as applied as normal practice.

By C. H. HERTZ, Junr. and Associates; published by Mining and Metallurgical Advisory Boards, Pittsburg, Pennsylvania, U.S.A.

On the Viscosity of Acid and Basic Open-Hearth and Cupola Furnace Slags in Molten State

This work describes a study of the viscosities of acid and open-hearth and cupola furnace slags, using the rotating cylinder method. It is wellknown that the refining action in the open-hearth furnace is influenced to a considerable extent by the fluidity of the slag, and the investigation reported in this work is a useful contribution to an important question.

The viscosities of acid and basic open-hearth slags and cast iron were compared. Unlike iron, the change in the viscosity of steel furnace slag greatly depends upon temperature, and the slags do not represent the distinct temperature of primary crystallisation. Acid open-hearth slag is shown to be more viscous than basic slag. Examination of the effects of fluorspar additions shows that fluorspar reduces the viscosity of basic open-hearth slags, while of the added fluorspar added about 15 to 16% remains in the slag. In investigations on acid slags containing various percentages of MnO, FeO, and MgO, it is shown that ferrous oxide decreases the melting temperature and improves the fluidity, while MnO increases both temperature and fluidity. It is shown that when MnO is used to displace FeO the viscosity is increased. In basic slags MnO improves the fluidity and lowers the melting temperature; a slag rich in MgO tends to be thin, but has a high melting temperature.

The viscosity change of acid and basic open-hearth slags during the refining period was investigated. In the oxidation period the viscosity of the slag is small because of the addition of metallic oxides, such as iron ore, scale, and fluorspar. But in the equilibrium period the viscosity of the slag becomes gradually thicker by increasing the concentration of acidity or basicity, the acid or basic contents being absorbed from the furnace banks. The effect of limestone added as flux in cupola furnace melting on the viscosity of slag and the properties of cast iron produced were investigated, a one-ton cupola being used. It is shown that slag which was obtained by adding 4% limestone to the charge has the smallest viscosity and the lowest melting temperature. Cast iron produced in this manner is stated to show superior chemical and mechanical properties.

By TATSUO MATSUKAWA; published by the Taniguchi Foundation for the Promotion of Industrial Progress, Osaka, Japan. (In English.)

Corrigenda

In connection with the article dealing with "Alloy Steels for Aircraft Construction," the author, Dr. W. H. Hatfield, has sent us a modification of some of the data given in one of the tables. The values given in Table I. for the following materials should read :—

Material. (All wrought condition except.†)	1. Specific Gravity.	2. Modulus, Tons/per Sq. In.	3. 0·1% Proof Stress, Tons/per Sq. In.	4. Maximum Stress, Tons/per Sq. In.	5. Fatigue Limit, Tons/per Sq. In.	Ratio 3/1.	Ratio 5/1.
Duralumin bar, 3L. 1	2·85 mx.	4,510	15·0	25·0	± 9·5	5·26	3·33
Super duralumin	2·82	4,510	18·0	30·0	±12·5	6·38	4·43
Y alloy bar (heat-treated), 2 L. 25	2·85 mx.	4,825	13·0	22·0	±10·0	4·56	3·51
†Aluminium-copper alloy (12% Cu) (2 L. 8)	2·90	4,920	—	9·0	± 3·0	—	1·04
R.R. 56 (forgings), D.T.D. 130	2·75	4,920	22·0	27·0	±11·5	8·0	4·18
Magnesium alloy (Elektron), D.T.D. 88	1·82	2,800	7·0	15·0	± 7·0	3·84	3·84
Ash	0·53	630	—	3·57	—	2·25*	—
Spruce	0·40	536	—	2·50	—	2·08*	—
Oak	0·69	760	—	4·00	—	1·95*	—
Teak	0·80	1,070	—	5·40	—	2·26*	—

* Proof Stress assumed ½ maximum stress.

Business Notes and News

Annual Excursion of the Staffordshire Iron and Steel Institute

The Annual Excusion of the Staffordshire Iron and Steel Institute was held on July 10, when a visit was made to Messrs. Steel Peech and Tozer and the United Strip and Bar Mills, Ltd. The party consisted of 53 members and friends and included Messrs J. T. Wright (President), T. G. Bamford (Vice-president), E. C. Rollason (Secretary) and the past-presidents T. Hoskison and A. E. Osborn.

The party was entertained to luncheon by kind invitation of the company. Mr. J. T. Wright (President) expressed thanks on behalf of the Institute, for the opportunity of visiting the works and for the cordial and generous hospitality. He said that some recent results achieved by subsidiaries of the United Steel Company must be of considerable gratification to the management and staff. At the Appleby works, a furnace operating the Talbot Hot Metal continuous process had produced no less than 2,950 ton of steel ingots in a normal working week. This was a fitting answer to those pessimists who regarded English practice as being inefficient and behind that of its continental competitors. The Templeborough works had also produced recently 1,625 tons of steel in a fixed cold-charged furnace—a world's record. In the absence of Mr. A. Williamson, Mr. Percival Smith (production manager) replied. The visitors were then shown round the works which proved of real interest and value.

Davy Brothers, Ltd.

We have been advised that Messrs. Davy Bros., Ltd., Park Iron Works, Sheffield, who have been operating under the management of a Receiver during the last 10 months, are now operating without any restrictions, as the Receiver has now been discharged by the Court. The capital of the Company has been reorganised, and sufficient fresh capital has been provided to ensure that work of any magnitude can be dealt with and executed in a way consistent with its long and progressive experience.

The new Board of Directors consists of Mr. E. J. Fox of Stanton Ironworks, Chairman, Mr. A. Peech of United Steel Companies, Ltd., and Mr. R. F. Norland of the Industrial Finance and Investment Corporation, Ltd. Under this new management such an old established Company will rapidly renew its old business relations and merit a larger share of work within its capacity. Many old clients, as well as prospective clients, will welcome the return of this Company to production on normal lines and will express pleasure at its reorganisation.

South Durham Steelworks Extend

Extensions at the Cargo Fleet Works of the South Durham Steel and Iron Co., Ltd., have been agreed upon and the company has decided to put down a modern semi-continuous billet and sheet-bar mill which will compare favourably with the most up-to-date plant of this description in the country. This step has been contemplated for some time, but it is probable that the recent agreement between the British Iron and Steel Federation and the International Steel Cartel has enabled the directors of the company to facilitate arrangements for the production of semi-finished steel to meet their own requirements. The contract has been placed with Dusseldorf specialists in this type of plant, but the extensive electrical equipment required will be supplied by a British firm. The erection of the new plant will occupy twelve months.

Atlantic Air Service

A transatlantic air service is contemplated by the announcement of the formation of the British Bellanca Aircraft Company with a capital of £400,000. Plans are being prepared for the erection of plant at Speke Aerodrome, Liverpool, for the construction of aeroplanes of various types. It is understood that the Company will build aeroplanes, not only for a transatlantic serivce, but for other purposes and if the negotiations are satisfactory, plant will be erected at a cost of about £100,000

In view of the progress so far achieved, since the first flight was made by aeroplane, it seems likely that a regular service across the Atlantic will be recognised as normal a few years hence.

Improved Results of General Electric

Presiding at the recent annual general meeting of the General Electric Co., Ltd., the Rt. Hon. Lord Hirst of Witton said the net profits of £1,184,483 exceeded the best year the company had ever had and, in his opinion, were due to three main causes: (1) The better conditions prevailing in the country, which had lifted the purchasing power of our people up to their former high standard; (2) better export business; and (3) improvements within the electrical industry itself. Their total exports increased over last year by 40%, but while they compared favourably with any of the last four years, they were not yet back to the former high standard of 1929-30. More and more of the Company's exports were going to the Empire, and in the year under review 69% of their shipments went to Empire countries, due to better economic conditions prevailing in the Dominions.

Dealing with progress in engineering he referred to the great progress in the Company's heavy engineering works, where new turbo-generators up to 60,000 K.V.A. are being built, and the largest mercury rectifiers required by the industry. Great success has been achieved in the equipment of complete electric ships. The establishment of the grid, whilst reducing the demand for generators, has made an ever-increasing demand for complicated switchgear. The mechanisation of coal mines is progressing satisfactorily. The equipping of steelworks with rolling mills, electric furnaces, and endless other applicances form an important part of the Company's activities, and every problem that had been encountered has been met.

Railway electrification is now coming into its own, and the trolley-bus is quickly superseding tramways, both at home and overseas, and the future prospects are reasonably bright·

Rolling Mills Fusion

The amalgamation of Darlington Rolling Mills Co., Ltd., with F. R. Simpson and Co., Ltd., under the title of Darlingtou and Simpson Rolling Mills, Ltd., has been announced. F. R. Simpson and Co. are a well-known Midland firm of re-rollers engaged in similar class of work to the Darlington concern, and the amalgamation involves the acquisition of J. and W. Marshall, of Walsall.

It is anticipated that the unification of interests will enable a greater volume of work to be secured and undertaken in the rolling of light sections. Both the Darlington works and the works of F. R. Simpson and Company will continue operations, but it is probable that the Walsall works of J. and W. Marshall will ultimately be closed.

Darlington Rolling Mills are jointly owned by Messrs. Dorman, Long and Company, Ltd., and the Crittall Manufacturing Company, and Sir Valentine G. Crittall will be chairman of the new company. One of the terms of the amalgamation is an undertaking by the Crittall Manufacturing Company to take 75% of its requirements in casement sections from the new company, thus assuring it of an outlet for a substantial tonnage.

Guest, Keen & Nettlefolds, Ltd.

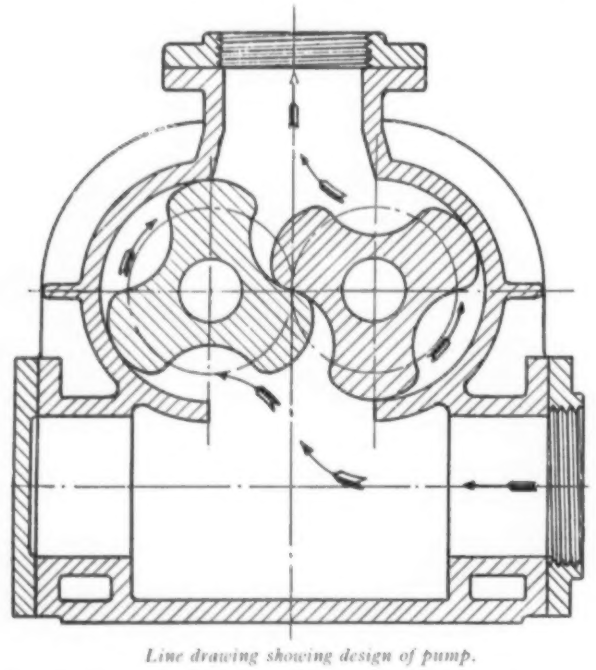
A substantial increase in profits is shown by the results of the financial year of Messrs. Guest, Keen and Nettlefolds, Ltd., presented at the recent annual general meeting. It is noteworthy that the increase in profits has been contributed in varying degrees by nearly all the many separate entities this Company controls. In such a large group as is represented by the Company it must have been a source of pride to Sir John Field Beale, the Chairman, to be able to report that every one of its subsidiary companies had made a profit.

Commenting on the steel trade prospects, Sir John considered them to be particularly bright. The Company, he said, is successfully emerging from a period when ability to give employment and pay dividends was at the lowest ebb—not from any fault in the management and direction but from lack of "confidence." The general re-organisation of the steel trade has made food progress during the year throughout the country, and progress in the future should be more rapid under the able guidance of Sir Andrew Duncan, the newly-appointed independent Chairman of the British Iron and Steel Federation, working with its President, Lord Dudley, and Sir William Larke, as director.

Pumps for Coke Oven By-Product Plant

For handling tar, creosote, wash oil, benzol, toluol, fuel oil, and heavy residues in connection with coke ovens considerable interest attaches to the latest design of Holmes-Connersville cycloidal 3-lobe "Type SO" high-speed rotary pump, manufactured by W. C. Holmes and Co., Ltd., of Huddersfield. Essentially the principle of the "SO" pump is the use of two cast-iron impellors of special shape, each having three lobes, on the general lines of the "Roots" blower, which always interengage with one another without actually touching, whilst rotating at a high speed in opposite directions, being each fixed on separate parallel shafts.

The arrangement is contained within an outer cast-iron casing with the inner surface of which the impellors also constantly interengage, as well as with each other. Also the two impellor shafts, which run in roller or sleeve bearings, are connected together outside the casing by totally enclosed gear wheels, which in turn are driven through a single short shaft in any convenient manner, such as by a direct coupled electric motor on the same baseplate. The workmanship is such that the impellors have a clearance between the two at all points of about 0·002 in., and the same applies to that between the impellors and the casing. A high volumetric efficiency, however, is obtained, since the liquid acts as a seal, while the power consumption is very small, both mechanical and



Line drawing showing design of pump.

liquid friction being reduced to a minimum since no sliding or rubbing surfaces, valves, and ports are used.

The liquid enters at the top and discharges from the bottom, the pump therefore being aided by the action of gravity, with the stuffing boxes under suction. In operating the high-speed impellors alternately take in by suction, and discharge downward in positive fashion, a definite volume of liquid, no springs, valves, buckets or other complications being included.

Another important point is the flexibility so that a wide range of duty can be given by varying the speed of the motor, and inspection of all the parts is easy. The gears also act as a lubricant pump, drawing oil from a reservoir and circulating it through the bearings at the gear end, an oil bath being provided at the other end, while in most cases small air chambers are provided.

The pump is made in a number of standard sizes in three groups suitable for 120, 90 and 60 feet maximum head respectively, the speed being within the range of 175-225 r.p.m. maximum, according to the size. For example, one of the larger pumps for the highest head (120 feet) will pump about 2,000 gallons per minute calculated on material equal to cold water in weight and viscosity, taking 93 h.p. for the drive, and for thicker liquids the duty and also the speed of revolution is reduced accordingly.

£100,000 Steelworks Contract for British Electrical Firm

One of the largest contracts ever placed in this country for electrically driven rolling mill equipment for a British steelworks mill has just been awarded by Messrs Dorman, Long and Co., Ltd., to the General Electric Co., Ltd., of Magnet House, Kingsway, London, W.C. 2. Following on the recent completion of several other important steelworks electrification schemes, notably in South Wales and Yorkshire, the placing of this order, which is valued at approximately £100,000, affords a striking illustration of the industrial revival which is taking place throughout the country.

The equipment which will be installed comprises the very latest designs in this class of gear and includes such modern items as a complete mercury arc rectifier unit, which is probably the first instance of a unit of this type being installed in a steelworks. Of the huge electric motors which will be required, the largest is of 17,000 h.p. for driving a cogging mill. The shaft and armature of this machine will weigh about 35 tons, and in the course of its duty will be reversed from full speed in one direction to full speed in the reverse direction within approximately 10 seconds. The whole of the equipment will be manufactured in the General Electric Company's Engineering Works.

A further development is to take place at Palmers' works. The foundry is being extensively reconditioned, and, it is understood, will be restarted by Messrs. Vickers-Armstrong, who some time ago purchased the undertaking of Palmers Hebburn Co., which continued the Hebburn ship-repairing department of Palmers Shipbuilding and Iron Co.

Catalogues and Other Publications.

The importance of the term quality in its relation to products is gradually having increased significance as a result of facilities now available for careful testing and inspection. In this respect direct inspection of parts by means of radiography is proving valuable and in a booklet issued by Magnesium Castings and Products, Ltd., Slough, Bucks, Dr. N. C. HYPHER discusses the application of radiography to the inspection of magnesium castings. Dr. Hypher is consulting radiologist to Messrs. High Duty Alloys, Ltd., an associate Company, and has made a long study of the application of X-ray to the light-alloy industry, both in the form of shadow photography and in the application of X-ray spectroscope.

S.P. Foundry Pig Irons are described in a useful brochure issued by Barrow Hæmatite Steel Co., Ltd., Barrow-in Furness, Lancashire. They are low phosphorus irons. The different grades of this brand of pig iron are made entirely from ores, smelted with the best Durham coke in one of the most modern blast-furnace plants in Great Britain, and no steel scrap, cast iron, or any other ferruginous material whatever is used in their production. The "S.P." brand of iron represents the highest class of modern all-mine, hot blast, and sand cast pig irons which possess considerable toughness. Consequently, castings made with these low phosphorus irons are of a very high quality, free from porosity and particularly suitable for severe conditions involving pressure and unusual wear and tear, such as internal combustion engines. The booklet contains much technical information that is of real value.

The June issue of the Wild-Barfield Heat-Treatment Journal contains a very interesting and informative article by Mr. E. R. Gadd on "Maintaining the Quality of Aero-Engine Material with Special Reference to Heat-Treatment." Mr. C. E. Foster has a further article in on the subject of Pyrometry in Industry, which News from Scandinavia is published from Mr. Grini. Copies are available from Wild-Barfield Electric Furnaces, Ltd., North Road, London, N. 7.

MARKET PRICES

ALUMINIUM.

98/99% Purity		£100 0 0

ANTIMONY.

English		£75 0 0
Chinese		68 0 0
Crude		25 11 0

BRASS.

Solid Drawn Tubes	lb.	9d.
Brazed Tubes	„	11d.
Rods Drawn	„	8d.
Wire	„	7¾d.
*Extruded Brass Bars	„	4¼d.

COPPER.

Standard Cash		£31 2 6
Electrolytic		34 5 0
Best Selected		33 10 0
Tough		33 0 0
Sheets		60 0 0
Wire Bars		34 10 0
Ingot Bars		34 10 0
Solid Drawn Tubes	lb.	9¾d.
Brazed Tubes	„	9¾d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0 3 3
‡Ferro Tungsten	„	0 3 0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
NOMINAL: 2-4% Carbon, scale 11/- per unit	ton	29 15 0
NOMINAL: 4-6% Carbon, scale 7/- per unit	„	22 7 6
NOMINAL: 6-8% Carbon, scale 7/- per unit	„	21 12 0
NOMINAL: 8-10% Carbon, scale 7/- per unit	„	21 12 6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	34 0 0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36 5 0
§Guar. max. 0·7% Carbon, scale 12/6 per unit	„	37 5 0
‡Manganese Metal 97-98% Mn.	lb.	0 1 2
‡Metallic Chromium	„	0 2 5
§ Ferro-Vanadium 25-50%	„	0 12 8
§ Spiegel, 18-20%	ton	7 10 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	6 5 0
20/30% basis 25%, scale 3/6 per unit	„	8 17 6
45/50% basis 45%, scale 5/- per unit	„	12 15 0
70/80% basis 75%, scale 7/- per unit	„	17 17 6
90/95% basis 90%, scale 10/- per unit	„	28 17 6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	13 10 0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 4½
Ferro Phosphorus, 20-25%	ton	15 15 0
§ Ferro-Molybdenum, Molyte	lb.	0 4 6
§ Calcium Molybdate	„	0 4 2

FUELS.

Foundry Coke—		
S. Wales	—	1 5 0
Scotland	—	1 8 0
Durham	0 19 0 to	1 2 0
Furnace Coke—		
Scotland	—	1 5 0
S. Wales	—	1 0 0
Durham	—	0 17 6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)		£55 0 0
*Commercial Ingots		41 0 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0 0 9
*Cored Bars	„	0 0 11

LEAD.

Soft Foreign		£14 0 0
English		16 0 0

MANUFACTURED IRON.

Scotland—		
Crown Bars, Best		£10 5 0
N.E. Coast—		
Rivets		10 10 0
Best Bars		10 2 6
Common Bars		9 5 0
Lancashire—		
Crown Bars		9 12 6
Hoops	£10 10 0 to	12 0 0
Midlands—		
Crown Bars		9 12 6
Marked Bars		12 0 0
Unmarked Bars	from	7 5 0
Nut and Bolt Bars	£7 10 0 to	8 0 0
Gas Strip		10 12 6
S. Yorks—		
Best Bars		10 15 0
Hoops	£10 10 0 to	12 0 0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	9¾d.
†Sheet to 10 W.G.	„	11¼d.
†Wire	„	11¾d.
†Rods	„	11d.
†Tubes	„	1/1½
†Castings	„	1/-

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—	
Hematite M/Nos.	£3 11 0
Foundry No. 1	3 12 6
„ No. 3	3 10 0
N.E. Coast—	
Hematite No. 1	3 8 0
Foundry No. 1	3 10 0
„ No. 3	3 7 6
„ No. 4	3 6 6
Silicon Iron	3 10 0
Forge	3 6 6
Midlands—	
N. Staffs Forge No. 4	3 7 0
„ Foundry No. 3	3 11 0
Northants—	
Foundry No. 1	3 10 6
Forge No. 4	3 2 6
Foundry No. 3	3 7 6
Derbyshire Forge	3 6 0
„ Foundry No. 1	3 14 0
„ Foundry No. 3	3 11 0
West Coast Hematite	3 7 0
East „ „	3 8 0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron Kr. 103	
Billets Kr. 240-310	£12 7 6-£16 0 0
Wire Rods Kr. 290-340	£15 0 0-£17 10 0
Rolled Bars (dead soft) Kr. 200-220	£10 6 0-£11 7 0
Rolled Charcoal Iron Bars Kr. 290	15 0 0

All per English ton, f.o.b. Gothenburg. Converted at £1 = Kr. 19.40 approx.

SCRAP METAL.

Copper Clean	£26 0 0
„ Braziery	22 0 0
„ Wire	—
Brass	17 0 0
Gun Metal	24 0 0
Zinc	8 10 0
Aluminium Cuttings	66 0 0
Lead	12 0 0
Heavy Steel—	
S. Wales	2 15 6
Scotland	2 10 0
Cleveland	2 12 0
Cast Iron—	
Midlands	2 7 6
S. Wales	2 11 0
Cleveland	2 12 0
Steel Turnings—	
Cleveland	1 15 0
Midlands	1 14 0
Cast Iron Borings—	
Cleveland	1 5 0
Scotland	1 17 6

SPELTER.

G.O.B. Official	—
Hard	£11 15 0
English	14 18 0
India	13 0 0
Re-melted	14 12 6

STEEL.

Ship, Bridge, and Tank Plates	
Scotland	£8 15 0
North-East Coast	8 15 0
Midlands	8 17 6
Boiler Plates (Land), Scotland	8 10 0
„ „ (Marine) „	—
„ „ (Land), N.E. Coast	8 10 0
„ „ (Marine) „	8 17 6
Angles, Scotland	8 7 6
„ North-East Coast	8 7 6
„ Midlands	8 7 6
Joists	8 15 0
Heavy Rails	8 10 0
Fishplates	12 10 0
Light Rails ......£8 10 0 to	8 15 0
Sheffield—	
Siemens Acid Billets	9 2 6
Hard Basic ....£6 17 6 to	7 2 6
Medium Basic..£6 12 6 and	7 0 0
Soft Basic	5 10 0
Hoops..........£9 10 0 to	9 15 0
Manchester	
Hoops..........£9 0 0 to	10 0 0
Scotland, Sheets 24 B.G.	10 10 0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to $\frac{3}{16}$ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅛ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£231 5 0
English	231 10 0
Australian	231 12 6
Eastern	230 15 0
Tin Plates I.C. 20 × 14 box	18/2

ZINC.

English Sheets	£22 15 0
Rods	28 10 0
Battery Plates	—
Boiler Plates	—

*McKechnie Brothers, Ltd. July. † C. Clifford & Son, Ltd., July. ‡ Murex Limited, July.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, July.